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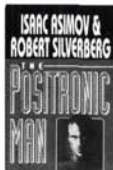
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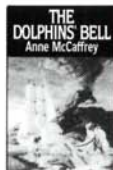
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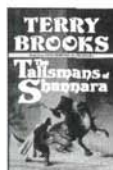
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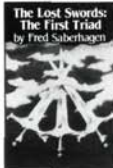
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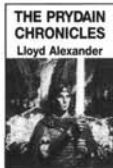
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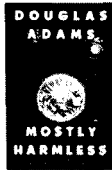
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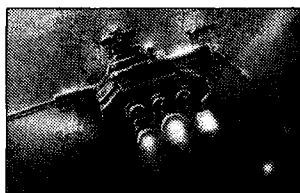
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SCIENCE FICTION AND FACT



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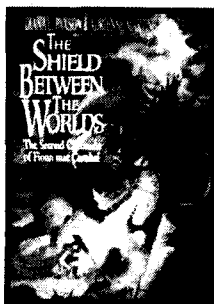
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TOO OBVIOUS TO SEE

It's been said that a fish could never discover water. Being perpetually and completely surrounded by the stuff, the hypothesis goes, it would only be aware of things that were *different* from water.

Like any simile or metaphor, of course, it isn't perfect. Fish are very sensitive to *differences and changes* in water, such as currents, pressure differentials, and the faint taste that a salmon follows upstream to its own natal headwaters for spawning. Presumably a smart enough fish could infer the existence of the medium itself from such things, much as humans discovered air by the observation of things like winds.

Still, there is a certain amount of truth in the saying. It is easy not to notice things you've always been surrounded by. So it is that the inhabitants of most human cultures regard their own ways, no matter how peculiar they might seem to outsiders, as Universal Human Nature. And so it is

that when people go looking for ways to conserve resources and reduce pollution, they can easily overlook things that could make sizable contributions, simply because the habits are so widespread and deeply ingrained that it never occurs to anyone to consider changing them.

One example I mentioned earlier in these pages was the matter of shopping bags ("Bag Limit," August 1990). Americans had become so accustomed to having the store provide a new, disposable bag every time they bought anything that it took them a long time to suspect even dimly that the difference between plastic and paper was trivial compared to the difference between disposable and reusable.

No doubt there are still many such changes that individuals could make in their habits to help conservation efforts. But there are also a good many things done by *big* wasters and polluters that hardly ever get mentioned. Yet when you think about

them, they seem so obvious that you're likely to wonder why nobody has been making loud demands that they be changed.

For instance, has it ever occurred to you—perhaps while being exhorted yet again to set your thermostat still lower in winter or higher in summer—that these days most business and public buildings are drastically overheated in winter and overcooled in summer? Quite possibly not—not because it isn't true, but because you've been so conditioned to taking offsetting measures that you don't even notice the irony of routinely doing things that are completely at cross purposes.

A highly air-conditioned building may not be uncomfortable if you're wearing a couple of layers of shirt and a jacket and tie. But those things will surely be uncomfortable outdoors on any normal summer day in New York or Washington or Cincinnati. Therefore it's not uncommon to see business commuters in such places carry a suit coat to a car or train, put it on when they reach the office, and take it back off when they leave.

Thermodynamically, this makes no sense whatsoever. The *rational* thing to do, for those places that still think

they need dress codes, would be to change the dress codes to encourage attire that makes sense outdoors, and reduce the air-conditioning level so it would be comfortable indoors, too. Since we're talking about large numbers of *big* buildings, equivalent in their energy usage to many private homes, the immediate result would be a substantial saving in energy use. A side effect would be an increase in employee comfort and morale, which could very well translate into a fringe benefit of increased productivity. I realize that many managers think that any relaxation of dress codes would somehow lead to a *decrease* in productivity, but I've never seen any convincing *evidence* that it would. Who has done the experiment? Who is likely to?

Heating and cooling are some of the heaviest energy users among normal human activities. Anything that can be done to reduce the need for them is likely to be a worthwhile contributor to reducing resource use and air pollution. Another that may come to mind is a corollary of the one above. Grocery stores are particularly bad offenders when it comes to overcooling. Many kinds of food *need* to be kept cold; customers and employ-

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ers, but there's still plenty of room for improvement.)

The question of overheating or overcooling people in their workplaces raises an even more fundamental question: how many of those people even need to be *going* to work? This, of course, also bears heavily on the question of how to reduce petroleum use and air pollution from cars. Obviously most people need to work, but how many of them really have to go to a centralized location to do it?

A significant number of employers and employees are already finding that a good many jobs can be done, in part if not entirely, at home. (One recent survey I saw claimed that approximately a third of Americans are now working at least partly at home.) If that number increases, as it can and

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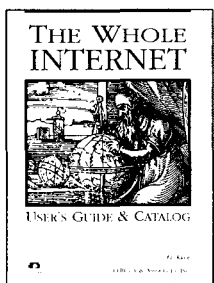
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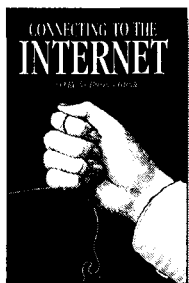
You've read about cyberspace in classics from William Gibson and Bruce Sterling. That's still science-fiction, but it's not far off, once world-wide networking comes together with "virtual reality."



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probably will, the mere fact of “keeping them off the streets” should dramatically reduce both car use and the need to heat or cool huge buildings. As I write this, the governor of New York has just signed legislation requiring employers to reduce car use by their employees, by such means as aggressively encouraging carpooling. Carpooling would help, but if *nobody* in a potential carpool has to drive, that will help even more.

Some jobs, of course, do need to be done in central locations with special equipment. Much manufacturing fits this description. But one sometimes wonders how much energy and material might be saved if manufacturers were closer to sources. Admittedly one of the great virtues of technological civilization is that it makes it possible for a person with an idea in place *A* to implement it with materials from place *B* and sell it in place *C*. But is it really necessary for a breakfast roll made with oranges from Florida and eaten in New York to be baked in Minnesota, with some or all of the product being trucked all over half the country? Or for chocolate to come from South America via Switzerland or Belgium?

I also see a great deal of unnecessary and wasteful duplication of services and information. My local newspaper, which often carries feature articles about How We Must Conserve, Economize, and Clean Up, often delivers two or three copies each of several of the advertising fliers in its Sunday edition. I've never seen any sign that anyone on the staff is conscious of the irony in this. But it

doesn't stop there: the same paper also publishes a special advertising-only paper (ironically titled *Money-saver*) that carries still more copies of the same fliers and is delivered “free” to everybody in the area, whether they want it or not!

A recent news story announced that the U.S. Department of Agriculture will now require all packages of raw and partially cooked meat and poultry products to carry instructions for safe handling and preparation to minimize bacterial risks. The article included the text of the required labeling; it amounts to a lengthy paragraph. Certainly this is information anyone cooking the stuff should have; but is it really necessary to duplicate it, wasting paper, energy, and ink, on *every single package sold*? It is not specific to any particular brand; it is general principles, already available in lots of places, including cookbooks and frequent feature articles in newspapers and magazines. If people are too stupid to learn it and act on it, it is not the government's job to keep hitting them over the head with it; and it probably won't do any good, anyway. Yes, I do remember what it's like to be a beginning cook. I also remember considering it my own responsibility, and no one else's, to learn how to do it right.

That observation brings us back to actions individuals can take—but sometimes those actions depend on the availability of suitable equipment that will never be widely used unless companies manufacture it. Consider, for example, the frequent advice to run water only when you're actually

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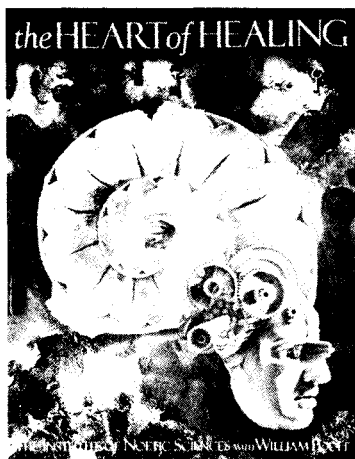
using it during dishwashing, shaving, or toothbrushing. Makes sense, but if you try turning off the water every time you don't actually need it running, you'll probably find that quite a bit runs during the times your hand moves back and forth between the faucet handle(s) and what you're working on. So why should you have to use the faucet handle to turn the water on and off? Where is the obvious solution: handles used only to adjust temperature, with a *pedal* to start

and stop flow no matter how wet, dirty, and/or busy your hands are?

Just a few examples of things businesses could be doing to help conserve and clean up. They may sound obvious when they're pointed out, but chances are you've seldom heard them mentioned before. But I suspect that if people do start thinking about them, the "little guy" is going to be less and less inclined to go any farther until the "big guys" start doing their part! ■

The past does more than influence the future—it *makes* the future. Each human being alive changes the direction of the racial animal, to some extent or another; and necessarily, a multiplication of factors that come from the growth of the race itself—including the mere number of people alive—puts increasing pressure on the individual to develop a larger sense of responsibility towards all other humans, the environment, and eventually the entire universe.

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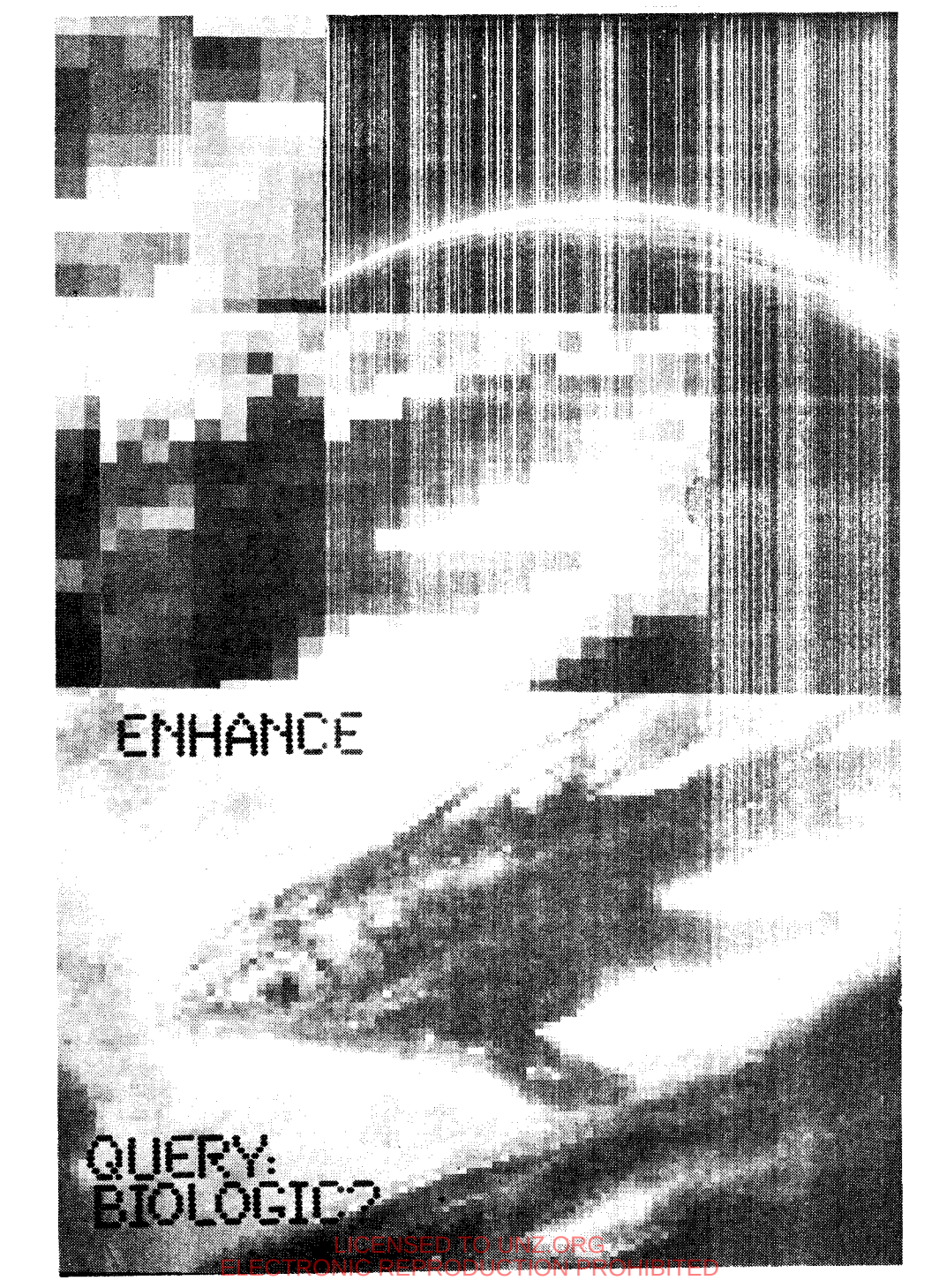
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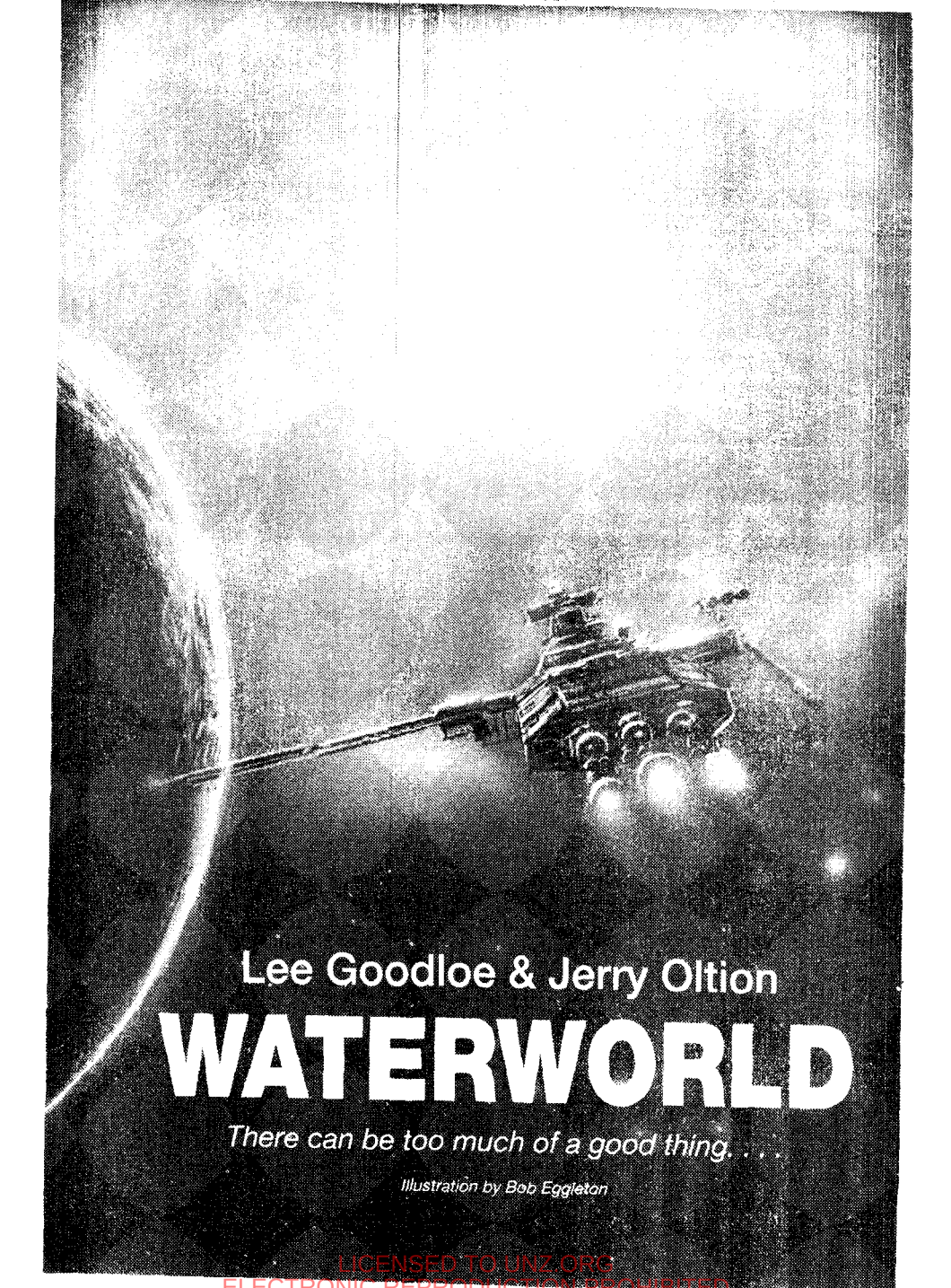
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WATERWORLD

There can be too much of a good thing. . .

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Alone, alone, all, all alone,
Alone on a wide, wide sea!
And never a saint took pity on
My soul in agony.

—Samuel Taylor Coleridge,
Rime of the Ancient Mariner,
Part IV, Stanza 3

Norman Gomez stank. He reeked. He exuded an aroma that would have driven rats away, but he barely noticed. Indeed, it would have been hard to detect such a subtle addition to the general environment, for his office stank, his surroundings stank, the whole ark stank, with a miasma so pervasive it had sunk below consciousness. Most of the time.

Other times it was all he could do to keep from gagging. Today was such a time. Perhaps it was the smell of fear, he thought. No one had ever held open a bottle labeled *fear* and wafted its vapors beneath his nose, but Norm knew the odor anyway. He'd tried to ignore it, then tried to control it, then tried to deny it, but nothing had worked. At last he had admitted the truth: he was afraid of dying. But even his admission didn't alleviate the smell.

He leaned back and examined again the glistening scar on the bulkhead across from him, only a tiny part of the hasty patches to the gaping wound in the ark. The nanofabs had sealed it seamlessly, but they'd had to scavenge for raw materials and hadn't been able to match the old hull's composition. At least it held air. If only it could hold back the memories, too.

Death had come knocking, with a

fist. Some bit of gravel had slipped past the shielding while they were cruising at 10 percent of lightspeed. With the kinetic energy of a small nuke, the piece of grit had ripped a great rent along the ark, like a knife gutting a trout. Nearly all of their air had spilled out to interstellar space, along with most of their water and much of their organics. And also most of the crew.

As he always did when he thought of the accident, Norm remembered Teresa. Teresa of the dark hair and laughing eyes; Teresa, and their plans for starting a life in their new world. *Men do not weep!* he told himself sternly, as his eyes threatened to mist up again. He'd have liked to cry, though, if just for the feeling of moisture on his cheeks.

The colonists who slept in SloMo in their zero-g cocoons at the ship's center had been spared, but for how long Norm couldn't say. The ship had been a wonder of recycling technology to begin with—it had to be, to make the years-long trip between stars with live cargo—but after the collision they'd learned what recycling really meant. The four surviving crewmembers lived off gardens and 'cyclers throttled down to the absolute minimum, and at that, they could only buy a little time. Time to retarget; time, hopefully, to make an emergency stop to replace their volatiles before the ark's biosystems broke down completely.

Norm couldn't see the baleful red eye of their new destination from his office. He could have done so if he wished to call up an image on his

monitor, or he could have gone down to the lowest level of the ark's rotating life system to peer out directly into space, but he had no need for visual confirmation of what he already knew. He had just finished another round of navigational calculations; he knew precisely where the target star was, and how far away.

They would live to reach it, he had discovered. It was a straightforward enough calculation. They would even have a few weeks—maybe even a few months—to explore when they got there, to search for an ice moon or a captured comet from which to extract the water and gases they so desperately needed.

Yes, they would live at least that long, provided they hit no more gravel on the way, but that was by no means assured. They were traveling much more slowly now, but with the drive trailing behind them in braking mode they were even more vulnerable than before. True, they had tons of mass in the outer hull for radiation shielding, but that wouldn't stop another meteor strike. And they'd been hit once already. . . .

With a deliberate effort, he shook himself out of that train of thought and concentrated on the headband that linked his mind to the ship's database. He had work to do, as they approached this new star system. They were drawing close enough to catch the first faint planetary spectra in the telescope; soon they would know whether they could find what they had come for. It wasn't at all certain; a red giant should have baked out its system thoroughly when it first began

its expansion. They'd probably find nothing but dry rock, cinders that had once been planets. The odds were long against them, but it had been their only choice. Mary had been right about that, as much as it pained him to admit it.

Mary. He scowled when he thought of her. Mary the thinker, Mary the scientist.

Mary the reason they were in this mess in the first place.

Mary Hopkins pressed her face down into the tomato plant and inhaled. The tart, pungent, somehow fuzzy aroma of growth overrode—momentarily, anyway—the stink all around her. She smiled, remembering the hours she had spent in her mother's garden, pulling weeds from between the rows. She had always known when she pulled a tomato by mistake: she'd imagined its intense perfume to be some kind of olfactory death rattle. Every time she smelled it she'd wondered why the plant itself should have a fragrance so distinct from the fruit it bore. Maybe just to be different, she supposed, exhaling softly and inhaling again before raising her face back out of the tank.

The plant looked awful: scrawny and malformed, with its two largest leaves yellowing to uselessness and not a single bud promising to replace them. A lone blossom drooped from a dispirited stem, and even as Mary brushed it carefully with pollen from its neighbor, she wondered if there was any point in doing so. At this rate the plant would be dead before it could produce fruit. She and George

and Norm and Ivan would probably be dead by then too, so what did it matter?

Because they might not die, that's what, and if they didn't then they would need this scrawny tomato, and more like it, for seed stock to replace what they had lost. The nanofabs could make all the tomatoes they wanted once they got the raw material, but the library's single template wouldn't provide the diversity they needed once they got the colony going. Only a healthy population of breeding stock could do that. Mary didn't believe for a minute that a red giant's planetary system would hold any kind of recoverable water, but it was just barely possible, and as long as there was any hope at all, she wasn't going to give up.

She heard footsteps on the stairway. She could tell by their heaviness whose they were, and what kind of a mood he was in, too. She looked up from her tomato as he stepped through the doorway.

"Hello, Norm."

"Your comparator program doesn't work," he said without preamble.

She felt a brief surge of panic. "The comparator? What's wrong with it?"

"It should be finding planets by now, and it's not; that's what wrong with it." Norm stopped about three paces away from her, just close enough so he could look down the front of her shirt as she knelt beside the garden.

Mary counted to about twenty-five, thinking: *Of course the program's at fault, then. It couldn't be Ivan's telescope nor George's command inter-*

face; no, if there's a flaw in the system then it's Mary's fault. She said, "Maybe you're using it wrong."

"I am *not* using it wrong. I know how to run a simple program—"

"And I know how to install one. The comparator works. I tested it thoroughly."

"Then why does it find no planets? There should be at least one gas giant in this system, shouldn't there?"

Norm's belligerence forced her to voice the thought she'd been keeping to herself for days. "I don't know. Should there? There's no law I know of saying every star's even got to have planets, much less gas giants. That's why we came here in the first place, to see what we'd find."

That wasn't the answer Norm wanted to hear. He took a step closer, stood over Mary with his hands clenched. "You will test the program for errors. I order it."

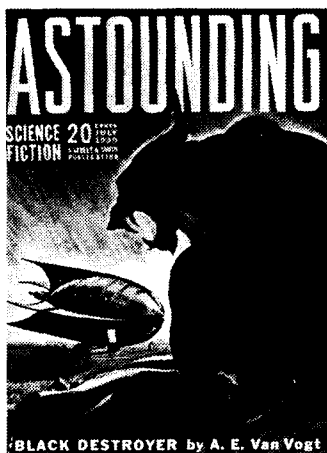
Mary raised up and looked Norm straight in the eye. She knew he hated it when she did that. In his world view a man had to be at least ten centimeters taller than a woman. "Who died and made you captain?" she said, enunciating each word.

He hated that even more. Unclenching his fists, but only because honor forbade hitting a woman, he said, "Debug the program." Without waiting for an answer, he whirled around and stomped away. Mary heard him kick the door open at the top of the stairs.

Idiot. So ruled by his glands and his ridiculous machismo that he couldn't even function in the company of a woman. Mary figured the only way

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he'd been able to reconcile himself to having a female captain on the colony expedition had been to sleep with her, and the moment she died he'd claimed the position for himself. Mary wondered why such a man had been chosen to crew a colony starship, but she knew the answer: guys like Gomez were good at surviving once they got where they were going.

Yeah, but at whose expense?

Mary laughed out loud. "Theresa only slept with you to keep you from mutiny, Norm!" she shouted at the empty corridor.

Ivan McGuire heard the shout all the way down the hall in the nanolab. He shook his head at the silliness of it all. Couldn't those two understand that their petty feud was only adding to all their problems? Things were tough enough without having interpersonal tension to deal with, too. But then, they had been at each other's throats even before the accident; there was no reason to expect them to change now. Contrary to popular belief, adversity seldom brought out the best in people.

It would be nice if they could at least agree on the obvious, but that seemed beyond them, too. Inevitable as it was, the decision to stop at the red giant had not been simple to reach. Ivan remembered the argument clearly, with the meticulous, sharp-edged detail of a memory implanted while under the mindlink. Of course he hadn't actually been in anyone else's mind, but they'd all been linked to the database and some spill-

over was inevitable. He'd been aware of George's amusement at the ridiculous turn his life had so recently taken, of Norm's grief and anger and fear, of Mary's deep terror beneath her inevitable bluster; all filtered through his own combination of shock, anger, alarm, and—yes—fear as well.

The degree of linkage was just enough to allow that awareness, but not enough to allow direct mental communication. The mutual awareness allowed them to cut through subterfuge and misunderstanding—most of the time, anyway—but the separation kept them thinking independently. It had long ago been discovered that when communication became too intimate, innovation ceased. Individuals needed to remain individual to gain the advantage of different viewpoints, experiences, and prejudices.

Even with the link, it was like meetings all through human history: the advantage went to the strongest personality. If there was more than one strong personality . . . well, the meetings took longer. Occasionally a better decision even came out of it.

The review of facts had been short. With their mindlink, everyone had immediate access to the same basic information. As he'd sat at the round table, watching his three sweaty shipmates scratch under their thick headbands, Ivan had suddenly known that the rest of the ship's repairs could safely be left in the hands of the robots and the nanofabrication cells, that the expected lifespan of the biosystem was now less than two years,

that even if all four of them went into SloMo they could only extend their time by another six months, that their original destination was still over seven years away—the data had gone on and on, including the information that they were within half a light-year of the red giant star they had intended only to fly past en route to their final destination. That wasn't so coincidental as it seemed: space is dirtier near stars, so if they were going to be hit, that was the most likely place.

Nor was their being there a coincidence, either. Colony ships always had funding problems, so when the university had approached the mission planners with a proposal to combine a scientific mission with their colony expedition (“just a five-degree deviation in course, and with the gravity assist it will only cost you a month's time”), the mission planners had agreed without hesitation. The ship would make a close flyby through the red giant system, and they would take along a colonist-scientist to run the instrumentation.

Mary was that scientist. A graduate student at the university, she'd had the necessary skills to head the project, and she was one of the few who looked at the colony project as an opportunity to start another university rather than exile to the frontier.

As their first post-disaster planning session had gotten under way, Ivan had tried to guess what she thought of the project now. He'd known what Norm thought, that Mary was responsible for the disaster, but he'd wondered: Did Mary think that, too? The

mindlink was just tenuous enough that he couldn't tell.

She had been the first to speak of possible alternatives. “We could re-target for the giant,” she'd said.

Norm had jumped on her immediately. “Looking for volatiles near a red giant would be pointless,” he'd said. “Things will be baked out there already.”

“Not necessarily, Norm. Outer planets might survive. Gas giants—”

Norm had let himself slip, then. “*Dammit*, Mary! You know we can't get gases out of a deep gravity well.”

His blush had been a thing to behold. What was going through his head at that moment? Ivan had wondered. By the sense of shame seeping through the mindlink, Norm was almost certainly berating himself for swearing at a woman. Such lofty ideals! Ivan wondered if he would indulge in self-flagellation in the privacy of his own quarters. So silly. So much easier to admit one's faults and learn to live with them.

Mary had hardly noticed the swearing anyway. “Norm, gas giants aren't the only things in a solar system. Most of them probably will have shriveled after the star expanded anyway. The inner ones won't be giants any more. Besides, the outer ones may still have icy moons.”

“We're a dead ship if we can't think of something better than the red giant,” Norm had insisted stubbornly.

“We're all ears,” Mary had said then, and God knows, they'd all tried to come up with something better. They'd considered ramscoops to collect interstellar gases; they'd looked

at freezing the colonists down from SloMo to true NoMo to save resources; they'd toyed with drawing straws and dying "like men" (Norm's idea) so a few could live to the end of the trip, but in the end they'd knocked holes in every argument they'd presented. The numbers for ramscoop size versus gathering ability simply didn't add up; a frozen body was a dead body and everyone had known that since the early twenty-first century; and the maximum number of sleepers the ship could deliver alive to their original destination without replenishing water and air was far less than the amount needed for a colony.

They were going to have to retarget for the giant. None of them liked the idea; Norm *hated* it when Mary was right with one of her shots from the hip, and neither Ivan nor George nor even Mary herself liked the idea of looking for water around a red giant. But what else could they do?

We could learn to get along in the process, Ivan thought, but he knew that the odds of that were even less than the odds of finding water.

George Nakamoto was not a nervous man. Serenity and harmony, the virtues cultivated by his Japanese forebears and drummed into him during his upbringing, had taken to that degree. But sardonic cynicism was his substitute for true serenity—just as it was for Westerners. No doubt his grandfather would have blamed such unbalance on his mixed parentage.

But if harmony was the crux of ex-

istence, why had his ancestors left Japan in the first place? Or ridden a starship to one of Earth's first colonies? Same reason he was on *this* ship, a second-wave colonist himself? If so, then it was closer to boredom than it was to harmony.

Meditation was still a valuable ability, though, even if seldom practiced. He took a deep breath, exhaled it slowly, took another—

A knock at the door interrupted him. He sighed in irritation, made a futile attempt to banish that emotion, then said, in resignation, "Come in."

The knob turned and Mary pushed the door open. "Have you got a minute?" she asked.

George sighed again, his hope of inner peace fading. He waved Mary toward the bunk—the only other place to sit in his room besides at the desk. "What's on your mind?"

She sat down. "The telescope," she said. "Norm claims there has to be a bug in the comparator program because it's not finding any planets. I've tested the software over and over, and it's right. So—"

"So it's got to be the telescope," George finished for her.

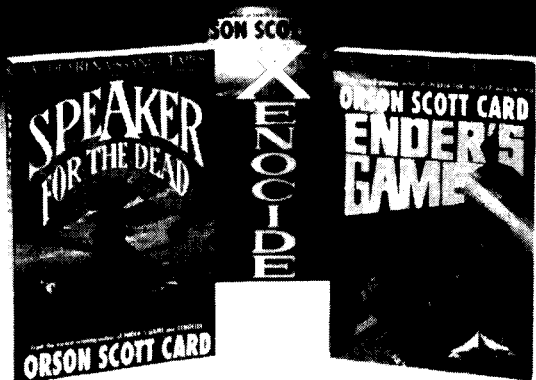
Mary shrugged. "Well, yeah. It's got to be. Either in the instrument itself or in the interface."

George felt a vague amusement. "Such a curious position for you to be in, wanting Norm to be right!"

Mary glared at him, but she remained silent.

George grinned at her, although a part of him sneered at himself for indulging in putdowns. Even if Mary had come barging in with an accusa-

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tion, that was no excuse for causing her gratuitous discomfort. Especially in a tiny shipboard environment. He banished his grin and said quietly, trying to take the sting from his earlier mocking, "I understand why you want the results to be wrong. We're committed to stopping; planets or no. In a few days we've got to go into SloMo and wait for the computer to finish the trip for us, and if there's nothing there we're out of luck." He looked at his desktop, bare except for the flatscreen monitor folded into its surface and the headband resting beside it. Without looking up, he said, "Unfortunately, for our peace of mind at any rate, both the telescope and interface are OK. I've tested them as thoroughly as you've tested your comparator. You can tell Norm that if the system is seeing nothing, then there is nothing there to see."

Mary stood up. "You're right, but would you please tell that to Norm, too? He won't believe it from me, especially since it's bad news." She looked straight at him until he turned to face her again.

George reacted differently to that gaze than Norm would. Where Norm saw hostility, he saw pain, and it made him feel even more guilty. He nodded. "Sure, Mary, I'll do that."

"Thanks." She opened the door and stepped out, then stuck her head back inside. "I mean it," she said, and then she was gone.

The very deep did rot; O
Christ!

That ever this should be!

Yea, slimy things did crawl

with legs
Upon the slimy sea.

—Part II, Stanza 10

The deepswimmer had risen too high. A sluggish blimp of flesh, as large as the ancient Terran airship whose form evolution had unconsciously mimicked, it struggled frantically to stop its ascent, to flee back down into the safety of the cold dead deep water. But it was too late. Hunger had driven it higher than usual in its search for microorganisms, well up into the aerated water where the carnivores lived. It could hear their sonar pinging, a crescendoing cacophony as more and more of the swiftkillers detected the lumbering deepswimmer and immediately zeroed in on it.

The swiftkillers slashed by, slicing out ribbons of flesh, greedily snapping after the meat. Severed pieces drifted only seconds before being gulped down in their turn. Blood trailed like streamers from the deepswimmer's wounds, pooling into a fog, shrouding the places where chunks of flesh had been torn out. The cloud was invisible in the lightless water, but it might as well have been luminous, shouting its chemical signals into the water, a windfall of organic matter for the perpetually starved upper ocean.

The great beast thrashed in helpless agony, the cloud of blood growing thicker, the number of swiftkillers—swarming to it like terrestrial moths to a light—ever larger. Now and again one swiftkiller slashed another in passing, and a mini-frenzy

would erupt as the other swiftkillers turned on their wounded comrade.

The feast lasted for hours. But at length the frenzy eased, the blood cloud began to thin, and a few engorged swiftkillers began to leave. But before the blood had dispersed too much, scavengefilters swarmed through, armored against the slashing death, greedily straining the blood and shreds of flesh out of the gory water. A late coming swiftkiller, still hungry and driven to distraction by the smells in the water, attacked one of the filters before instinct could stop it, but its teeth barely scraped the filter's chitinous armor before the filter discharged its internal battery into the swiftkiller's body. Suddenly numb, the swiftkiller drifted downward, but only momentarily, until set upon by its companions. No other swiftkillers were so foolish, or so unlucky, as to tangle with the scavengefilters.

And after another hour, there was nothing left even for the filters.

The swiftkillers resumed their restless cruising, ranging all the way from there at the bottom edge of the oxygenated layer of water to the surface tens of kilometers above. Searching, searching, searching for anything that moved, for anything made of something besides water. Bits of falling organic matter, other creatures, dead or living—even small meteorites that managed to survive the trip through the corrosive atmosphere and acidic water—all provided food for the ever-starving denizens of the planet-encompassing ocean.

* * *

Water, water everywhere,
And all the boards did shrink;
Water, water, everywhere,
Nor any drop to drink.

—Part II, Stanza 9

Mary stared out the port, tweaking the zoom for a better look. The view was promising. The *Cabeza de Vaca* had established polar orbit about a planet that looked remarkably Earth-like, at least if you ignored the reddish-yellow illumination. If she switched off the room lights her eyes would soon adapt so she could do just that, but she didn't bother. Red or white, the sight below was the most beautiful thing she'd seen in months. Sheets of fluffy clouds Coriolis-spun into storm whorls, with dark ocean below occasionally reflecting sunlight. Nothing *but* ocean below, by the look of it. Maybe they had lucked out after all. God knew, they were due for some luck.

Well... She stretched her arms wide, yawning. She'd just awakened from SloMo, and was still getting her brain and body back up to speed. *You can't tell much just by eyeballing the monitor*, she told herself. *Have to get to work.*

She sat down at her desk, put the headband on, and keyed the ID/initialization command into the desktop. Her surroundings faded—not so much visually as in importance—as she digested what the ship's sensors had already recorded.

She saw that the planet had low density, just from the *Cabeza de Vaca*'s orbital parameters. That meant it wouldn't have much of a rocky

core. Presumably it had started out as an ice-rich ball, something like the Jovian moons Ganymede or Callisto in the Home System, and had thawed much later when its sun ran out of hydrogen fuel and expanded into a red giant.

Mary checked to see what the ship had found about the rest of the system: Two rocky planets in closer, much closer. One was about Earth-sized, about one AU from the star; the other was about the same distance from its star as Mars from Sol. The same stellar metamorphosis that had thawed this outer world had turned the close ones into cinders. If they had oceans now, they were lava oceans.

No gas giants, she noted with satisfaction. Norm would be pissed. He'd never apologize, but he'd know her comparator program had worked.

The ship's computer had obviously made the right choice, bringing them here. No place else in the system had the volatiles they needed. Mary returned her attention to it. They were going to need atmosphere composition and density, water composition—hmm. It sure *looked* like water oceans on the world below them, but she'd better check that, too.

She started collating information, mentally directing the acquisition of new data. It would have been nice to have a sampling laser, just zap a point on the surface and read an emission spectrum. But the original mission was supposed to be a fast flyby from light-hours away, not a close study, so they hadn't brought such equipment, nor the templates for the nanofabs to

make it. Templates for scientific equipment were expensive.

Anyway, plain old reflectance spectroscopy should be plenty, even in red and IR wavelengths—the only ones the dull star put out in any quantity.

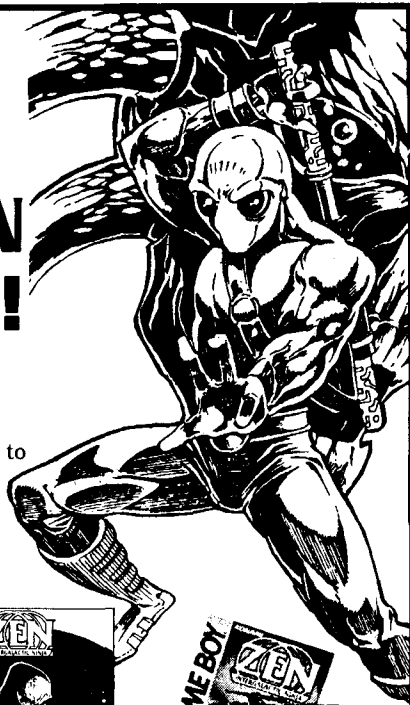
Time ceased to flow, as always happened when a person sank into a task using the mindlink. It could have been minutes or it could have been days, but eventually Mary had the results of the reflectance specs.

Bizarre. She shook her head at the analyses. Oxygen, carbon dioxide, nitrogen, virtually no argon or other noble gases; traces of carbon monoxide and sulfur oxides. So far so good, but why so much oxygen? She ran a quick calculation, pulling out the models from the computer's database. No, it couldn't be from photodissociation. This ember didn't put enough UV to sunburn a butterfly, much less split a water molecule and blow the hydrogen away into space. Life, then? Maybe photosynthetic microbes. She felt some excitement at the prospect of discovering the first extraterrestrial life, but it was excitement tempered with the knowledge of their predicament. Maybe someday somebody could come back to investigate, but the moment the *Cabeza de Vaca's* crew regained what they had lost, they would have to return to their mission.

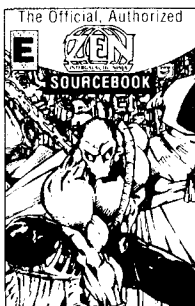
It was hard to determine atmospheric pressure with the instruments she had at her disposal, but she could estimate with pressure-broadening on some of the spectral lines, check that against atmospheric stellar

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occultations. With dawning misgivings, she considered her preliminary results. There was a *lot* of oxygen in that atmosphere. In fact, with the low surface gravity, that meant even more than the pressure alone suggested, because the air density dropped off so slowly with height. That atmosphere was *deep*. As she thought, the numbers worked themselves out in her mind, as the mindlink automatically performed the calculation.

She gave a low whistle. Maybe their luck wasn't so good after all.

Half an hour later she sat at the meeting table, Norm and George and Ivan already mindlinked and looking at her expectantly. She considered making a joke: *I have good news and bad news*. No, she thought, shaking her head. Humor can lighten things up, but it's not the right time.

She cleared her throat. "Well," she said, "we've found our volatiles. Liquid water, even. But it looks like they won't be easy to get. I've prepared a briefing in the database."

The others acquired rapt expressions for a minute as the onboard database briefed them.

When they'd absorbed the information, everyone looked at Mary again. "As you can see," she continued, "it's a chemical cauldron down there. The total pressure is over five atmospheres, with a *hell* of a lot of oxygen—something around 70 percent. Apparently there are some primitive photosynthesizers down there."

"How can that *be*?" Ivan asked. "They showed long ago that oxida-

tion of surface materials limits oxygen content in an atmosphere. Especially if there's life. It would burn itself up! Something's wrong with your calculations."

Mary snorted. "The numbers are right. Based on the planet's density, it's got very little rock inside. It was probably mostly ice before it melted when the star went red-giant. Thus, there's probably nothing *but* water at the surface. Anything that was going to oxidize did it long ago, so the oxygen just built up."

George closed his eyes momentarily, link-thinking, then said, "If your density figure is correct, then that ocean is not only worldwide but very deep."

"That's right," Mary agreed. "Probably hundreds of kilometers deep. A solid bottom probably just forms when a high-density ice phase becomes stable. Ice V or ice VI or something. Depends on the temperature at the sea bottom."

"We're getting off the subject," said Norm. "We have a planet that's *made* of water here. It looks like our prayers have been answered. Why is there a problem?"

"The oxygen pressure," Mary replied. "Virtually everything becomes not just flammable, but explosive in an atmosphere like that. Our equipment will burn up before it can even reach the surface."

There was silence around the table for a minute. Then Norm demanded, "How can you be sure of those pressure estimates? The briefing indicated there's a great deal of uncertainty in them."

Of course Norm would contest the results. Mary sighed inwardly. She could have said white is white, and he would have argued with her. With as much patience as she could summon, she said, "Yes, there is slop in the estimates. But you saw in the briefing how much error is probable. Maybe a factor of two either way. But whether it's two atmospheres of oxygen, or ten atmospheres, it's not going to make any difference! Things like metals and plastics become explosively flammable."

"I think it would be prudent, to say the least, to get some ground truth," Norm pronounced. "Remote sensing often leads you astray. Especially when your instruments aren't designed for it. An awful lot is riding on the calibration of instruments doing things they really weren't designed to do."

And especially when a woman tells you things you don't want to hear. Mary bit her lip. "What do you suggest, then?" she made herself ask mildly.

"Use one of the shuttles," Norm replied promptly. "Get some *hard* data. Before we build up a new bogeymen for ourselves, we need to have some better information."

Mary reddened. "Damn it, Norm, you can see the data as well as I can!"

Ivan said, "Why don't we build better sensors instead?" But he realized his mistake almost instantly. "Ah, templates. We don't have the templates."

"That's right."

There was silence for a moment.

"Mary," George asked, "what's

wrong with sending a shuttle down?"

"We'll probably lose the shuttle, that's what."

"Better risk a shuttle than risk the entire ship. We don't have time to mess around. Besides, Norm is right. Do you really have a factor of two confidence in your measurements? It seems like it could be an order of magnitude at least."

Before she could defend her figures, Ivan said, "And anyway, even if we lose the shuttle, it's not critical. We do have the templates for more shuttles, and the raw material. Better to lose it than more water."

Norm, for once, had the sense not to say anything.

Outnumbered, Mary said, "All right, you win. But you'd better get the nanofabs going on a new one, 'cause I can guarantee you it'll burn."

The fair breeze blew, the white
foam flew,
The furrows followed free;
We were the first that ever
burst
Into that silent sea.

—Part II, Stanza 5

The communications room felt crowded. It wasn't really—there was room for way more than four people—but any room with both Mary and Norm in it felt crowded anyway, at least to George. Especially when one of them was about to prove the other wrong.

"Aluminum should be OK; it's coated with a microlayer of oxide, just from exposure to the air," Norm was explaining to no one in particu-

lar. "Hell, that's why it doesn't catch fire in ordinary air. The oxide coat can't burn, and that protects the rest of it." George looked up from his telepresence controls to see Mary looking skeptical, as usual. He rolled his eyes. Norm could say that water was wet and Mary would look skeptical.

Ivan, standing by the monitor bank, smiled at George's gesture and shrugged as if to say, "Not my department."

George turned back to the final checkout. He would be flying the shuttle via a microwave mindlink, and if there were any glitches in the communications channels, he wanted to know about them *now*. Flying by remote was tricky enough without equipment problems to complicate things. At least from low orbit the lightspeed lag wouldn't be noticeable, not even with the relay satellites, but he'd never before flown the configuration they'd decided upon, so his reflexes would be slow.

They'd had the nanofabs build a "J-5 Floating Instrument Platform," basically a raft perched atop aluminum pontoons, which the shuttle would deploy while it hovered above the sea's surface. The platform held sensors for measuring the composition of the surface seawater, and also a "sinker," a heavy, instrumented probe that would measure water composition at depth and sonar-chirp data back to a transceiver on the floater.

And for the benefit of the four watchers, cameras would look around from both shuttle and floater with realtime imaging, each view ap-

pearing on one of a bank of monitors in the wall in front of them.

"Whenever you're ready, George," Norm said.

George nodded without looking up. "Just a minute." He finished checking the backup comm channels, then put on the heads-up telemonitor helmet. "OK. Here goes." He breathed deeply and slowly, willing his mind into the state where the VR link felt like a natural extension of his body. *Serenity, unity. . .*

He imagined himself looking out the shuttle's windshield; in an eye-blink his screen showed just that view. He reached for the throttle and attitude controls, lit the engine, and the shuttle moved away from the starship.

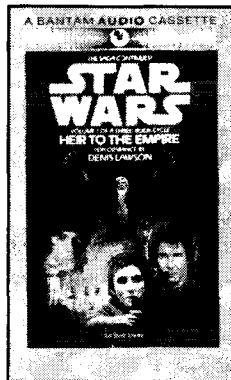
The descent was normal enough. He had to take it slower—the atmosphere was both deeper and thicker than he was used to—but that presented no unusual problems. The shuttle had plenty of fuel, and as far as he could tell, Norm's assessment of the oxidation problem was accurate enough. Within an hour he had brought it to the surface, and all its systems were still working perfectly.

"Deploying balloon," he said, and the mindlink translated his wish into the command. From the shuttle's upper cargo bay door, a heavy-lift balloon began to inflate with helium. George lowered the engine thrust to compensate for the lift as it filled, until a few minutes later he shut the engine down completely.

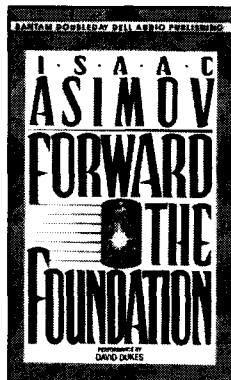
"Releasing floater," he said, shifting his point of view to the shuttle's underside camera.

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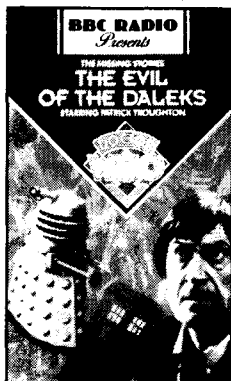
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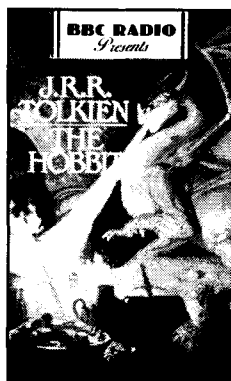
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The instrument platform dropped half a dozen meters, slapped down gently into the side of a wave, and rode over the crest. Monitors came alive with images; George switched his heads-up display to the main on-board camera and his point of view began rocking up and down with it. Enough data came in through the mindlink to make him feel almost as if he was there. The view was nearly Earth-like: a seascape with gentle swells, catching flecks of sun as they stretched off to a comfortably distant horizon. A soft hissing sound came through the intercom; probably one of the instruments, or maybe just the susurrations of the waves.

But George had no time to admire the view. He immediately began invoking the analyzer programs that controlled the instrumentation. He looked through his heads-up display to the data monitor as it began filling with tables and columns of numbers. Atmospheric composition: 67% O₂, 31% CO₂, 1.5% N₂, traces of noble gases, water vapor, nitrogen oxides, ozone.... The numbers flickered back and forth as the instrument package constantly updated them in realtime. Someone whistled slowly when the atmospheric pressure value appeared: 5.2 atmospheres. Right on Mary's estimate.

Meanwhile, another monitor was also filling with information: seawater composition, dissolved gas content, pH.... Someone else whistled when the pH value scrolled up. The ocean was about as acidic as gastric juice.

Now the atmospheric reading was showing traces of hydrogen. Hydro-

gen? In *that* atmosphere? Puzzled, George looked again at the air composition readings. Something nagged at the back of his mind; acidity, hydrogen, aluminum—

Elementary chemistry came flooding back as the comm link picked up on his new train of thought and fed him information from the main database. Hydrogen ions in acid solutions react with active metals to release metal ions—and gaseous hydrogen. Good God! The floater was dissolving in that acid sea!

And the reaction also produces heat. *Lots* of heat. And with all that oxygen around, the situation couldn't last long.

Quick, deploy the sinker! he commanded the computer, but before it could comply his viewpoint lurched crazily, and half the other monitors spun as well. The intercom filled with crackling noises. Then a sheet of fire billowed up along one side of the floater, and his heads-up helmet display went blank. He looked through it at the monitor bank, where three of the camera views were also blank, the screens now hissing with static. The remaining views shifted even more dizzily, offering glimpses of the sky, sweeping wildly along the horizon, dipping momentarily under the water where dark shapes, fast and unrecognizable in the dim light, flitted in and out of the camera's field of view. One by one, each view washed into static.

The last view from the remaining camera showed a mouth with multiple rows of big teeth, approaching, engulfing... then the scene also van-

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ished into static.

The others' reactions filtered in through the mindlink. "What the—?" "Told you so." "Christ, what was *that*?"

George, momentarily stunned, shook his head and then returned to his teleprojection, shifting his perspective to the shuttle nose camera as he did so.

A bizarre scene appeared on the sea surface. Appalled, he saw flaming pieces of the floater skittering around atop the sea like water drops on a hot plate, practically exploding as hydrogen bubbled up around them to catch fire. Pursuing them, nightmare shapes seized, ripped apart, and gulped the pieces of flaming metal with apparent impunity.

When the feeding frenzy died, George muttered, "I'm getting outta there." He switched his attention to the shuttle's flight controls. *Start the H₂ flow and just give her a little squirt of antiprotons, just enough thrust to hold it while the balloon—*

There came a blinding flash, and the shuttle monitor abruptly went blank, as did the entire telemetry stream.

Stunned again, George just sat for a moment, his mind as blank as his monitors. Then he tore off the comm helmet and growled, "What the hell happened?"

"The shuttle blew up," Mary said with an air of self-satisfaction.

George said nothing, just lowered his head into his hands. Insensitive bitch; he felt as if a part of himself had just died, and all she could do was gloat because she'd been right. He

willed himself again to breathe deeply and slowly, trying to recover his equilibrium, to cut through the disorientation.

"Did you get any data from the sinker before the floater blew?" Norm interrupted.

"No." Either it never got free, or whatever was in the water had clobbered it right away. It really didn't matter which. It didn't matter. . . .

Norm persisted. "Did we get any data before the shuttle blew up? What caused it to go?"

George finally looked up. Norm stood over him like an inquisitor, fists clenched. Behind him, Mary was actually grinning. Next to the monitors, Ivan was tapping instructions into a keyboard, not bothering with the mindlink. "Probably a hydrogen leak somewhere," Ivan said as the monitors switched off. Norm turned his attention toward him, and George sighed in relief.

Ivan said, "Enough must have diffused out of the tank to set up a little chemical explosion in the shuttle itself. And *that* let out the antimatter." He laughed, a little grimly. "At least the explosion will have wiped out those things ripping the floater apart."

"Hah," Norm grunted. "What about the acidity? Where did *that* come from?"

Ivan didn't have an answer, nor did George. Mary put on a mindlink and closed her eyes. A moment later she snorted, "Obvious. Should've been obvious, anyway. All that oxidation. Most of the nonmetallic oxides that dissolve . . . sulfur, nitrogen, whatev-

er...make acids. That's got to be where it comes from."

She dug obliquely at Norm. "The Universe always has these tricks up its sleeve, when you go bopping blithely into something you don't understand."

Norm snapped back, "If it was so obvious, Mary, how come you didn't see it? You were supposed to be figuring out the surface environment."

She just glared at him for an answer. Everybody knew the reason: the mindlink and the computer behind it would answer just about any question you could think of to ask it, but you had to think up the question yourself. The mindlink wasn't an artificial intelligence; it had no initiative of its own.

Norm looked away from her, saying, "And *life*. How can there be life? This planet would have been a ball of ice till its sun went red giant, and that can't have been more than a few hundred million years ago, at most. There hasn't been *time* for life to develop."

Ivan said, "We knew there had to be some life to make all that O₂."

"So there were microbes. Not monsters. How can there be multicelled life?"

Shrugging, Ivan said, "The planet closest to the star is about Earth-sized, and this star was probably about like Sol before it went red-giant. Maybe the ice world was seeded beforehand."

George felt a shiver run through his spine. He sat up in astonishment. "You mean spaceflight? You think a spacefaring culture left things behind?"

Ivan shrugged again. "Well, I suppose that's possible, but I was thinking more of spores from the Earth-like world, preserved in the ice. Bacterial, fungal, whatever... that would give life a big head start when the ice thawed. It's happened before. In the Home System, viable spores from Earth were found on some of the ice moons around the outer planets."

Mary looked thoughtful. "Yeah, I remember that. There was a big sensation for a while, because it looked like we'd discovered extraterrestrial life."

Impatiently, Norm said, "It doesn't matter; we've discovered it *here*. So what do we do now?"

Ivan laughed. "We go down in history," he said. "Provided we survive long enough to get the word out."

Day after day, day after day,
We stuck, nor breath nor
motion;
As idle as a painted ship
Upon a painted ocean.

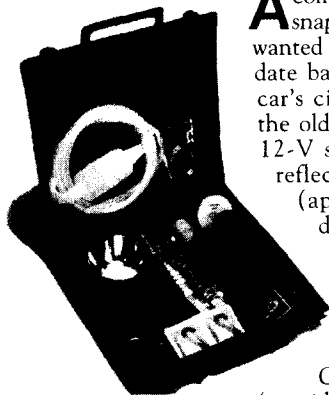
—Part II, Stanza 8

Norm was beginning to loathe the meeting room almost as much as he loathed the people in it. In the meeting room he actually had to link up with his three crew members, had to ignore their hostility and pessimism and weakness while attempting to use their group intellect to come up with a solution to their dilemma. He came away from each such meeting feeling soiled, befouled with a filth no amount of water would wash away.

But he could see no other choice. Four minds—even if three of them

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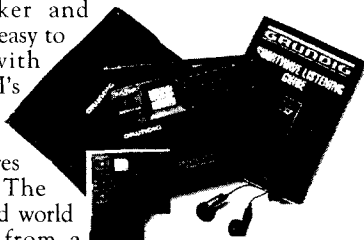


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were pitifully inadequate—were better than one when it came to brainstorming. He donned the link and said, “All right, let’s get this started. We’ve got to figure out a way to upload a couple million liters of concentrated acid through a couple hundred kilometers or so of high density oxygen mixture. As we’ve seen, shuttles won’t do the job. How about the skystalk?”

“It’s pure carbon, Norm,” Mary said. “Carbon burns.”

“It’s diamond fiber. Pure C-12,” Norm said as calmly as he could manage. “Diamond has an extremely high ignition point, uh...” He link-thought a moment. “Over 600° C. If we’re careful on descent, it shouldn’t get hot enough to ignite.”

George shook his head. “We’d have to take it in practically subsonic.”

“Yes, we would. Is that too difficult for you?”

George reddened. “I can do it. But that still doesn’t get us any water. The elevators are going to blow up just like the shuttle did.”

“Why should they? They aren’t hydrogen powered; they’re electric.”

“They’re aluminum. As soon as they touch acid, there’ll be plenty of hydrogen around. And once *that* starts burning, there’ll be plenty of heat to ignite the skystalk.”

“We can make them out of something else,” Norm said. “Iron—”

“Oxidizes,” Ivan interrupted. “And besides, it would be a bitch to program the substitution. Iron atoms and aluminum atoms are like apples and oranges to nanofabs.”

“You did it with the ship’s hull,”

Norm pointed out.

“Yeah, but patching a hole is a lot simpler than building an elevator.”

Norm said, “All right, then. Maybe we can’t build an oxygen- and acid-proof elevator. How about a pump? Can we pump the water up here?”

Mary snorted. “Thirty-three thousand kilometers to Clarke orbit? Do you have any idea what kind of pressure you’d have at the bottom?”

“We could use a peripump,” Ivan said. “It squeezes its cargo along, like peristaltic waves in the intestines. Each wave is a separate system, so the pressure doesn’t build.”

“That could take years.”

“No, more like months,” George said. “An industrial-grade pump could do it in... about seventy days.”

Norm took a deep breath before he spoke. “We only need to get it above the atmosphere,” he said. “Six hundred kilometers. That means—” he waited for the number “—about thirty hours. Then we can fill tanks in the elevator cars, and carry them up the stalk.”

“Thirty hours for the first liter,” Mary said. “Then we have to pump a million more of them.”

“Nearly... a million are already in the hose by the time the first one arrives,” Norm said. “If we want two million liters, we pump for thirty hours longer, then lift the hose out of the atmosphere and finish pumping from safety.”

“It could work,” George said.

“If the pump doesn’t burn first, or corrode,” Ivan said.

Norm called up the design parameters with a wish. “We have a template

for an acid-rated pump. Would that do?"

Ivan shrugged. "There's only one way to find out, isn't there?"

Mary had been rapt, listening to the headlink. Then she shook her head. "No, there isn't. You can check the materials parameters on the peripump. The thing's made of diamond fibers, just like the stalk. And it'll burn just like the stalk will. Even worse, the pump's got other organics in it, for the contraction fibers and what-not. It'll burn even better. I wish you guys would remember, that's not air down there. It's *oxygen*."

Silence for a moment, then Norm said, "Damn it, I'm tired of hearing what we can't do! What *can* we do?" He turned directly to Mary. "Do you have any better ideas?"

"Yes. We can build a non-flammable peripump."

"Don't be ridiculous! We can't design a completely new nanotemplate from scratch." Norm rolled his eyes in exasperation.

George asked quietly, "What are you thinking we could make it out of, Mary?"

"Ceramics. Oxides or silicates. They're fully oxidized already. In fact," she paused, "... plain old silica should work. The hose is only 600 kilometers long. Silica's strong enough for that, as long as it's completely bonded."

Ivan was shaking his head. "Where are we going to get... 200 tons of silica? We can't afford to make a trip to one of the inner planets. Even if the ship could survive being so close to the star, which I doubt."

"We've got more than enough silicates in the shielding mass. I checked."

"The shielding mass?" Norm asked, incredulous.

"That's right. It's nearly all ceramics, and we don't need it in the hull until we get back up to interstellar speed."

"You want to use all of our shielding mass to design, from scratch, a completely new peripump out of completely new materials?" Norm was practically shouting now.

Mary shouted back, "We won't lose the mass. We'll get it back when we leave. Which is more than will happen when you burn up our C-12 hose in that atmosphere!"

Ivan pointed out another objection, more quietly. "It'd have to be more than just a hose, Mary. We would have to thread the power wires and contractile fibers through the ceramics. That would be especially hard since silicates are insulators. And brittle."

She turned on him. "Yes, it would be hard. Would it be too hard for you?"

Ivan's lips tightened, but he said nothing.

Norm calmed himself enough to say, "This is a brainstorming session, not a debate. Let's table that idea and go on. What else can we do?"

No one said anything for a minute. Mary again acquired the rapt look of the mindlinked, then said, "All right. Here's another idea. We could blow up the planet instead."

"What?"

"I just checked the math. A series

of antimatter bombs at depth could theoretically lift a section of the surface into space. If we place the charges right, some of it could still be liquid when it gets here. Of course the shock wave would propagate all the way through to the other side with enough force to kill everything worldwide, but—"

George's eyes had gone wide. "You would destroy an entire planet for your own survival?"

"Of course not. I just said we *could* do it; I didn't say we *should*. This is supposed to be a brainstorming session, isn't it?"

"It is," Norm said, hardly bothering to hide his revulsion, "but we can do without that sort of input."

"I'm just following orders, Norm. You wanted to know what we could do, so I told you. I can't think of anything else." Mary started to remove her headband.

"You will stay linked!" Norm belatedly. "We need ideas. *Realistic* ideas, and you will help provide them. All of you will help think of ideas." He glared at each of the three in turn, challenging them to defy him. Mary held his gaze with her damnable blue eyes, but she also held her tongue. Ivan studied the table top. George radiated amusement, his head tilted slightly to the side.

Ivan said, finally, "Let's try the diamond pump. I think the risk is acceptable."

Mary started to speak, but George cut her off. "Mary, if it does burn, why can't we just try your idea then? As it is, you're saying we should spend our time trying to do something that may

not even work. And that we may not even have to do."

She shook her head vigorously. "Besides the waste of materials and time, the stalk's only meant to be deployed once. We're going to have a hard enough time trying to reel it back in when we leave. Not to mention the wasted reaction mass. It's not like dropping an anchor; the whole stalk is in orbit right now, and we have to brake most of it to a standstill when we drop it, then speed it back up when we raise it. Where do we get the reaction mass to do that twice?"

Ivan shook his head. "Mary, we don't have to reel the stalk back to install a new hose. That's what the elevator cars are for. George is right; we lose nothing by trying the simple solution first."

Exasperated, Mary said, "Yes we do. If we wait until later, there'll be that much more chance for something to go wrong when we try to install it. And we'll be under a lot more time pressure."

Ivan started to say something else, but Mary continued, "And besides, you're going to burn up almost our whole reserve of C-12 with that pump."

Norm leaned forward angrily, but George intervened again. "Mary, are you really that sure?" he said quietly.

Mary removed her headband and slammed it down on the table. "Yes, I'm sure. You can link to the data as well as I can."

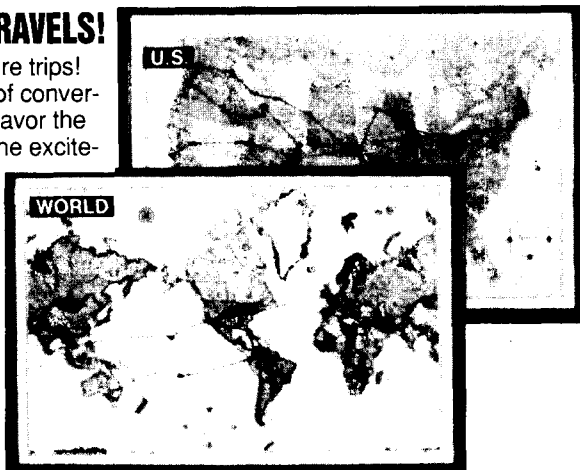
"Yes," Norm said, "but we can also reach different conclusions. I too vote to try the diamond pump."

Ivan had already said as much. All

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eyes turned toward George, who wet his lips and said, "I agree. But if it doesn't work, then I think we should try Mary's idea."

Ever the conciliator, Mary thought savagely. Couldn't he take a stand on *anything*? But she just said, "I think it's an unacceptable risk, and I want to log that."

She knew what they were thinking: *Mary is being a maverick again. She's just not a team player. She should keep personalities out of this.* Well, she'd be damned if she'd rubber stamp this asinine decision. Especially just to salve Norm's ego. In the name of "team play," they wanted her to confirm the collective CYA, even though there was no chance a board of inquiry would ever know—or care—what their decision was. Well, no way.

No one said anything as she stood up and left.

All in a hot and copper sky
The bloody Sun, at noon,
Right up to the mast did stand,
No bigger than the Moon.

—Part II, Stanza 7

The *Cabeza de Vaca* swung in Clarke orbit around Teresa—now the planet's official name, according to the captain's decree. Figures, Mary thought. Norm's image of the Ideal Woman. Pretty, deferential, tactful enough to seem dumb even if she isn't. . . . She knew it was petty to begrudge the dead woman her memorial, but even so, Norm's heavy-handed method of doing it stank.

When Norm wasn't around, every-

one still called the planet Waterworld. Mary pointedly did so even when he was. This latest scheme of his made her want to say a few worse things in his presence, but she'd already tried that and it hadn't helped either.

In the monitor before her, the sky-stalk stretched out from the cargo bay toward the planet, dwindling to invisibility long before it got there. It was actually two skystalks, one for up traffic and one for down, kept separate by the same electromagnetic effects that powered the elevator cars. The twin cable didn't look as if it were moving at all, and looks were nearly correct: George had slowed it from its initial thousand-kilometer-per-hour descent to less than three hundred as the pump-carrying end entered the upper atmosphere. Cameras along the hose's lowermost few hundred kilometers showed the receiving tank and the thin peripump leading downward to the cloud-speckled sea below.

"What's the temperature at the tip?" Norm demanded.

"Climbing slowly past minus forty," George said without looking up. "Only twenty degrees above ambient at that altitude. We're OK."

"Good."

They watched in silence as the hose dropped. It was a long wait; still, no one seemed inclined to leave, or even look away from the screens while their future literally hung from a thread. It seemed to Mary as if only a few minutes had passed when George said, "Slowing down now. Ten kilometers. Temperature plus thirty."

"What about that cloud?" Mary asked, pointing to one of the monitors. In it, a puffy yellow-tinged ball of cotton floated over the ocean almost directly beneath the hose.

"I think we'll miss it," George said.

"And if we don't?"

"Shouldn't matter."

"You sure? Lightning could—"

"Anyone can see it's not a thundercloud," Norm said. "It's too small."

"Hmm." Mary supposed she was just being paranoid. It was a tiny little cloud, and besides, the pump bristled with static discharge spikes, effectively making it a single enormous lightning rod.

It looked as if it would miss the cloud anyway. George called out the distance as the end dropped closer and closer to the ocean. The last few kilometers went excruciatingly slow, but finally he was calling out the distance in meters. "Thirty, twenty, ten—"

The static discharge whisker dangling from the bottom splashed into the water, then a second later the pump followed it in.

"Contact!" Norm announced triumphantly, overriding George's calm, "Splashdown." George took a deep breath, then said, "Commencing pump sequence."

They could see the hose's wake as it dragged through the water. Their orbital position wasn't perfectly still in relation to the surface, and in any event the stalk would shift its position as its mass balance changed. It didn't matter; as long as the end stayed submerged, the pump could suck in its precious cargo.

Provided whatever ate the lander didn't eat the pump, too. C-12 fiber was tough stuff, but the alien monsters had looked pretty tough themselves.

They could see the end of the pump start to flex. George, Norm and Ivan all cheered, but Mary said nothing; she was watching for motion in the water. Nothing showed for long minutes, then all of a sudden a shadow with teeth seemed to leap out of nowhere straight at her. She jumped back and screamed, just as the monitor filled with static.

"What was that?" Norm demanded.

"We're under attack," George said calmly. "It got the camera, but the pump's OK. Still—damn!"

"What?"

"End's plugged. Whatever it was, I think we sucked it in."

"Reverse the last wave," Norm said.

"Reversing. That ought to—what the hell?"

Mary was watching the scene from a camera higher on the hose, staring in horror at the water practically boiling with sharklike bodies, when a different shape rose out of the depths. It looked like a beach ball with wide, flat fins, which it swept back and forth through the water. The sharks gave it plenty of room, as if it were even more dangerous than they, and when it reached the pump, Mary saw why. The electrical arc she'd feared all along lanced out from the creature's body, and the monitor flashed and died. Mary looked to another monitor, this one showing a scene from a couple kilometers high. It took a moment for the image to register: a

brilliant white point glowed on the cable below, disembodied by distance.

Mary recognized the glow. She had once done a science experiment in school where they'd built an old-fashioned incandescent lamp, just like Edison had done centuries before. She'd accidentally broken the globe, and the filament had glowed momentarily white-hot, then winked out in its sudden exposure to air. This was like that; fire zipped upward along the hose, and in its wake the diamond fiber glowed brilliant white. Then the glow vanished abruptly, leaving behind not so much as a wisp of smoke.

The fire raced toward her vantage point, *toward her*—Mary ducked involuntarily, and when she looked up again that screen was also filled with static.

Only a few cameras remained, those at 50-kilometer intervals and the one inside the still dry water tank. Mary and her companions watched the flame engulf camera after camera as it raced up the hose, until it eventually burned itself out in the thin air somewhere between 250 and 300 kilometers up.

Mary turned to look at Norm. He was eyeing her already, holding himself braced for the blast he knew was coming. George and Ivan were actually cringing, as if they expected her to physically explode.

The image was so ludicrous that Mary burst into laughter instead. "God, look at you," she said when she could get her breath back. "You're pathetic. We're pathetic," she added generously. "One headstrong fool of

a settler and a bunch of yes-men. Well, get this straight, guys: the Universe doesn't give a damn about consensus. You're either right or you're wrong, and no amount of bullying or wishful thinking or team-play is going to change that. Until we start taking into account what's *really* down there, we don't deserve to succeed."

She turned away from them and stalked out of the room, slamming the door behind her. The slam reverberated through the repaired decking, and as the vibrations died away, the three men stole looks at each other.

"Well. Now what?" Ivan asked finally.

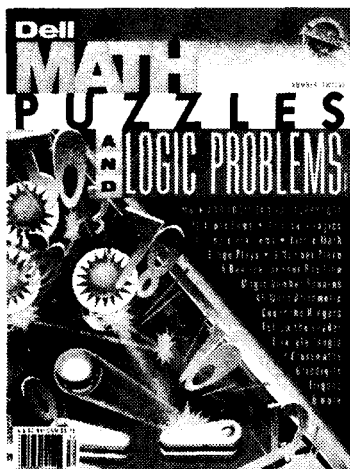
Norm had turned bright red during Mary's harangue. Now he slumped down into a chair, as though abruptly exhausted, and stared away from them, at the wall.

"All right," he said finally. "Build the damned non-flammable hose—if we can." He paused briefly, then added, "Mary knows everything. Or thinks she does. She can run the project. I won't be responsible for it."

Ivan peered again into the 3D monitor. Serrated arrays of multicolored balls marched off into perspective infinity in an intricate but ever-repeating pattern. He frowned slightly, and thought a command into the link. The crystalline pattern in the display shifted so rapidly and smoothly that the difference in the new configuration was hardly apparent. But Ivan was not bothering to visually scan the crystal model anyway. He was busy calculating parameters on it, strength/lightness, flexibility, fatigue

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life; and most importantly, susceptibility to oxygen attack. Sure, the silica backbone was impervious—after all, it was fully oxidized already—but did it sufficiently protect the embedded organic fibers?

“How’s it going?” An abrupt voice asked from behind. Ivan jumped, but from long habit, he saved the molecular design first before turning around. Mary stood behind his chair, her arms folded across her chest.

“OK,” he said. “It would be nice if you knocked first.”

Mary looked over his shoulder into the monitor. “What’s the coding?” she asked, pointing at the colored balls.

With a sigh, Ivan turned back to the screen and said, “The white balls are oxygen. They’re 4-coordinated with silicon; you can see the oxygen tetrahedra”—he pointed at them—“sharing every vertex. You can’t see the silicons ‘cause they’re enclosed in each oxygen tetrahedron. The whole structure’s basically a silica polymer.”

“Quartz?” Mary asked.

“No, more like cristobalite. We need a more open structure to thread the superconductors and contractile fibers through. The black is carbon, the red nitrogen,” he continued, pointing at an intricate lacework embedded among the white clumps of oxygen tetrahedra.

“Dammit, that won’t work!” Mary stated emphatically. “The structure’s too open. Oxygen’ll get in and fry the organics.”

Ivan’s lips thinned for a moment. He felt a surge of irritation, and even a flash of sympathy for Norm. “No,

Mary,” he finally said in as calm a voice as he could muster. “I *have* done the simulation. The gaps are too narrow for O₂ molecules to pass, and the tunneling probability is negligible. Would you like to see?” Without waiting for an answer, he thought a command through the link. The monitor picture changed; now the intricate crystal structure was almost invisible, hidden behind a swarm of jittering dumbbells—a simulation of gaseous O₂ molecules. “I’ve run this for simulated *days*, Mary! Nothing happens.” He knew he was going to regret it, but he couldn’t help saying, “Dammit, I know what I’m doing too!”

“Let’s hope so.” Mary watched for a moment longer, then turned and left without another word.

Afterward Ivan found himself shaking. Appalled with himself, he tried to will serenity, calmness, understanding—the sort of thing George talked about all the time. But it didn’t come. It would never come until the job was done, and maybe not even then.

George sat again at the VR console. He felt slimy and sweaty, and looked with loathing at the heads-up helmet. He could already feel it itching on his scalp. It wasn’t quite time yet, so he’d hold off putting it on as long as possible.

A camera at the base of the stalk showed Waterworld looming massively below, cruelly tantalizing with its ocean and clouds. It looked like they could just reach out and scoop up seawater. So teasing and yet so inaccessible, protected by acid and fire

like a treasure in some old fairy tale.

Ivan also watched, dividing his attention between George and the monitors in the room. Presumably Norm was watching too, but on a monitor in his cabin. He had refused to be in the same room with Mary ever since the debacle with the diamond peripump.

"Whenever you're ready, George." There was an edge in Mary's voice.

Mary's comment cut abruptly into his reverie. Since Norm's abdication of authority, Mary didn't even try to hide her contempt for the rest of them. She didn't seem to realize that the decisions hadn't been so clear-cut as she imagined. But history would judge that, too, he supposed. He tried to be charitable: being right had gone to her head. But still. . . .

"The hose isn't quite to the end of the cable yet," he said mildly. Not for the first time, George contrasted her—and Norm—with Teresa. Teresa had been a facilitator—she'd gotten along with Mary, even while sleeping with Norm—and she'd been a effective leader, too. More effective, in fact, with this group of egotists than the would-be autocrats who'd succeeded her.

But Teresa was dead. And the whole expedition was dead, too, unless this worked. The new silica hose was gliding down the skystalk on a string of elevator cars working in tandem, like porters carrying a snake. The multi-elevator approach was partly to spread the weight out so no one car was overtaxed, and partly to keep the hose from cracking like a whip. As its mass moved down the

elevator, it pulled the skystalk sideways with its added angular velocity, and the navigation computer had to compensate by accelerating the ship slightly, to pull the stalk taut again.

The computer would do most of the work of guiding the hose all the way down to Waterworld's sea, too, but George would be in the loop as a backup, in case the unexpected happened.

And God knew, there was ample chance of the unexpected.

He sat down and put on his helmet, glad, at least, to be escaping Mary's presence even if only through the mind link. He found, though, it took longer than usual to focus his mind into the link. Finally he directed his attention to the base of the skystalk, where the ballast mass hung, and where the new hose was approaching. The elevator chain had slowed down as the lower end neared the ballast, but finally the lowermost elevator let go of its cargo and the tip of the new silica-fiber peripump emerged beyond the end of the skystalk. Then the hose drifted uncertainly, like a puzzled snake. The ungainly trashrack on the end, an improvised ceramic cage to keep the seething predators out of the intake, sported a rocket engine whose nozzle looked a little like a bulbous snout.

Now, thought George, *it gets interesting*. Even just above the atmosphere, the hose tip still had angular velocity that needed to be canceled. So they couldn't go the last 600 km down through the atmosphere just by tweaking the trim masses on the skystalk. And they didn't dare try aero-

braking, not on their untried, ad-hoc design. No, they needed to use reaction mass, because they had to take the hose into the atmosphere at the lowest speed possible. Not because of the danger of ignition this time, but because silica was much less strong than diamond fiber. *One wrong move* and they could snap off a hundred kilometer length of it.

Which meant, even though they'd calculated the most fuel-efficient trajectory possible, they had to sacrifice the last of their water. They had nothing else that could be pumped through the hose. They didn't need much—the antimatter rocket engine ensured that—but then, they didn't have much.

To George, it felt like landing a 600-kilometer long flexible spaceship, in slow motion. As the sun gradually set with Waterworld's leisurely rotation, the cameras mounted along the hose itself all showed similar views: a slim bright line tapering into nothing against the utter black of the planet's advancing night side. Now and again a puff of brilliant smoke materialized against that blackness, a cloud of superheated steam exhaust flashing into ice crystals and catching the sun—another burst of reaction mass from the nozzle at the hose tip, braking its long descent to the planet below.

George couldn't tell how long he'd sat there, straining to stay alert, but the alarm buzzer brought him to full consciousness in an instant. Reflexively he shut off the valve feeding water to the engine, with the engineer's instinct of *first* stop the flow; *then* find

the problem.

Mary had been dozing in front of the monitor. She awoke at the alarm, or at George's curse, and said, "What are you doing, George? What is it?"

George was wondering the same. He scanned the displays, trying to identify what had gone wrong, while part of his mind noted wryly that Mary's immediate reaction wasn't too useful. If he'd already known what was wrong, was he going to just sit mum until she demanded an answer?

There! Stress in the hose; sensors showed the tension dangerously high at one point. Much more and the hose would break.

Heart pounding, he went to locate the problem. Their lives and their expedition now hung by a literal thread . . . if the stressed point was on the part of the hose that still lay alongside the stalk, they might be able to fix it. If it was on the part that was already down into the atmosphere, though. . . .

It was fifty kilometers up the stalk.

So. It could be worse; the problem might be reachable, if necessary. But what had happened to cause the stress?

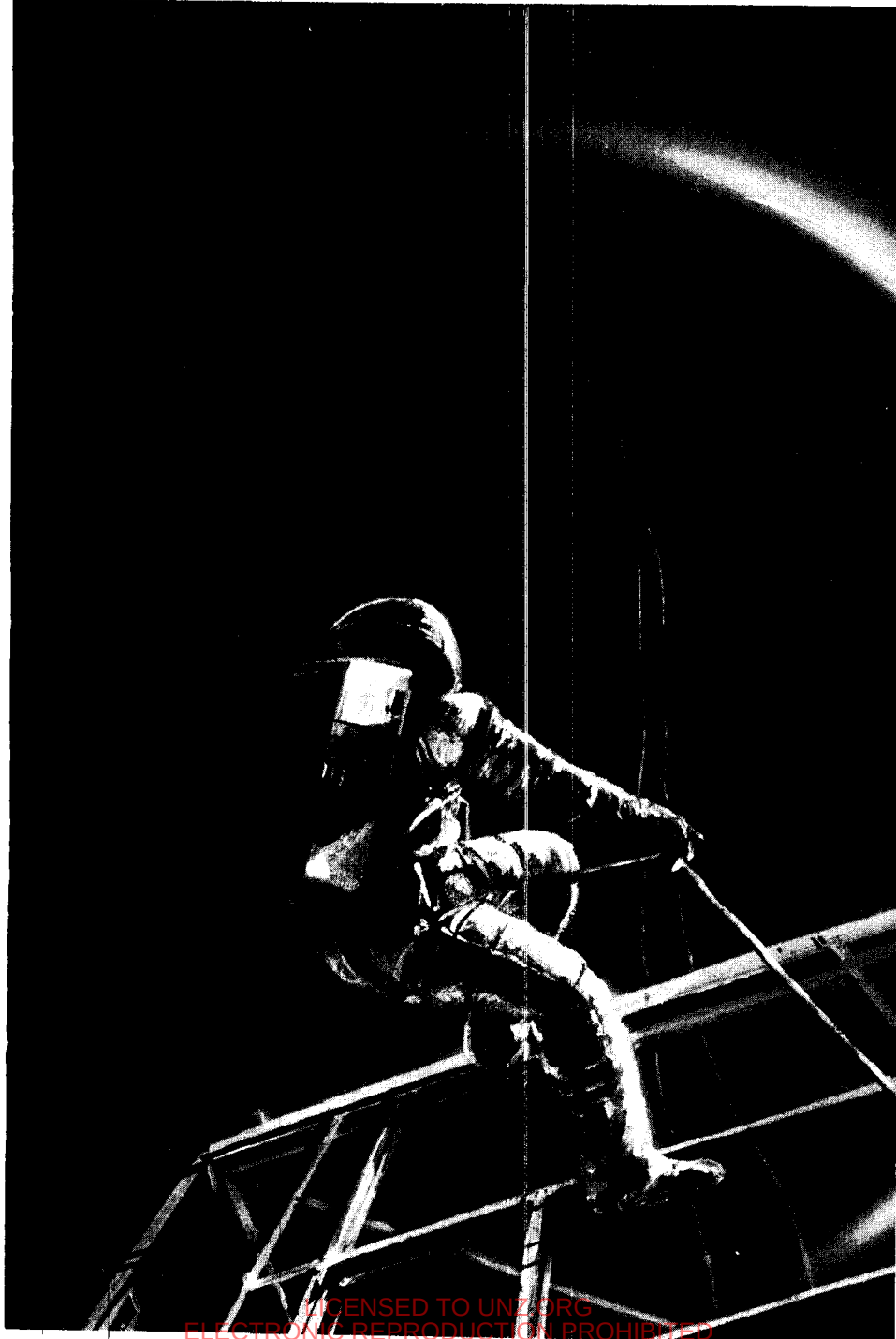
Ah, there it was.

"An elevator isn't moving," George said. "Nor responding. Something's stuck."

Ivan had awakened as well. "Can you fix it?" he asked.

"I don't know. There's not much to try here. I can try wriggling the hose by jiggling the other elevator cars, to see if that unsticks it, but—"

"Then do it!" That was Mary, peremptorily.



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George finished despite the interruption, "But I don't recommend it. We're simply going to break the hose. It's not likely to be able to take such treatment."

"He's right," Ivan said.

Mary had seemed about to blow up again, but then restrained herself with an effort as what he said registered. "What else can we do?"

"I can try to get the stuck elevator car to free itself."

"Do it, then," she said unnecessarily.

George did, but it quickly became evident that the errant car was not responding to any commands whatsoever from the controls.

"What now?" Mary asked George.

"What now? It's obvious." He avoided looking directly at Mary. "We have to go unstuck it."

"Good luck," Ivan's voice was strained over the radio, but Mary didn't acknowledge the good wishes as she climbed into the elevator car. The whole crew was there. Even Norm was watching, in person. She and he had drawn straws for the debatable privilege of riding down the stalk to fix the stuck hose. (They had to assume it was fixable. *Had* to.) Neither one of them was particularly happy with the result, but neither would suggest a switch.

The elevator car was an open-framed cylindrical cage about three meters tall and one and a half meters across, with two superconducting rings holding it to the cable. Cargo pods would normally be enclosed in the cage, or in the case of the hose

carriers, empty tanks to ferry the water back to the ship. Grapples for handling the hose had been attached to the outside. Mary's car was empty, and she rode inside, but there was barely room for her, perched atop a mass of tools, ropes, and such—anything she thought she might need. She fitted herself in as best she could, and then spoke a single word into the radio. "Ready."

"Here goes. Hang on." George's voice echoed in her ears. She felt weight settle on her as the car accelerated—slower than usual because of its human cargo, but still, within ten minutes she was traveling a thousand kilometers per hour and the ship's ungainly form was dwindling behind her. She felt light again as the acceleration shut off, then she struggled to move the tools to the other end of the cylinder. The next time she felt weight, it would be coming from the other direction.

The gaps in the cage were wide enough to fit through with only a little squeezing. She leaned out and looked down, down, *down* along the cables, twin threads tapering together with perspective against the disk of Waterworld, over ten degrees across even from her distance. Each cable was less than a centimeter in diameter, but even so the entire sky-stalk massed several hundred tons, all pure carbon-12. It was supposed to be a critical "bootstrap" piece of technology when they got to their destination, but it had never been designed for reeling back in.

If they couldn't. . . . She shook herself out of that line of thought. They

had more immediate problems.

But not so immediate that she couldn't catch up on her sleep. Even at a thousand kilometers an hour, it was still a thirty hour ride to the point where the hose was stuck, and she might as well get some rest. She wouldn't get any when she arrived, and besides, it would be more comfortable now while the gravity was still so low. But she was keyed up; the sight of the cables stretching away toward the planet kept drawing her attention.

Down, down. . . . She strained to see where the cables were leading, following them with her eyes. It was tantalizing: their tips just vanished against the disk of the planet. You couldn't really define, though, exactly where they became invisible.

Abruptly she realized she didn't remember the last few minutes, and that she was balanced precariously over the side of the cage.

And she was no longer in zero-g. If she fell out, she'd be in a separate orbit. It would still be close to the ship's, and they *might* be able to rescue her with a shuttle if she missed the atmosphere at perigee, but then they might not. And it would cost time and reaction mass they didn't have.

Norm would have the last laugh if that happened. Another good reason not to have it happen.

Shuddering, she pulled back in and clipped her safety belt to one of the cage bars, then she curled up atop her tools and fell asleep.

The insistent chiming of her radio alarm woke her from uneasy dreams.

Momentarily disoriented, Mary absently tried to scratch herself, but felt only smooth skinsuit under her fingers. She sat up abruptly as memory flooded back, and nearly teetered off the tool bundle. She grabbed at her safety line and at the cage, twisting her body back and wrenching her right arm as she did so.

"Coming up on the target," George said over the radio. His voice sounded amused; he'd probably been watching her from the elevator's camera, and no doubt had enjoyed watching her panic.

Well, screw him, she thought. She looked out at the other skystalk cable, the pump dangling alongside it, the elevator cars supporting it flashing by every ten kilometers or so. She was slowing down perceptibly.

She looked over the side. Waterworld was no longer a disk. Vastly larger, it was now a flat wall beside her, curving away toward the distant, atmosphere-fuzzed horizon. She was nearing the end of the stalk. George would bring her to a halt at the point where the other elevator car had failed, and from there she would have to search manually for the problem.

In a few minutes she felt the elevator begin to decelerate, adding to her weight as it did. Even after it stopped, she felt a sixth of a *g* or so from the planet itself, and that sensation triggered an unexpected wave of vertigo. Suddenly Waterworld was not a ball hanging in space; she was *up*, and it was *below*. Far below. Far, far, *far* below. With suddenly shaking fingers Mary double-checked her safety line. Nothing could save her if she fell

here. She'd plunge into the atmosphere like a meteor, her angular velocity carrying her away from the stalk as she did so.

She sat back and carefully looked out rather than down, trying to focus her mind on what she came for. She inspected the elevator on the opposite cable with the binocs built into her suit helmet, trying to will the shaking away. A deep breath, then another. . . .

George's voice broke into her thoughts like a clap of thunder. "Looks like you'll have to—"

"Shut up and let me think," she snapped at him. "I don't want to hear from any of you unless it's an emergency, is that clear?"

"Clear as vacuum," he said, and Mary heard the click of him disengaging his microphone. Good. One less thing to worry about.

The hose stretched parallel to the cable, held taut by the clamps mounted on the cage. George had backed the lower elevators up to relieve the tension in the hose, but ten kilometers of its own weight still pulled it tight below the clamp. Above it, though, the hose was slack, drifting slowly side to side as a long-period vibration ran up and down it.

The problem didn't take long to find. The elevator evidently had lost power, so its automatic braking system had grabbed onto the cable to prevent it from free-falling the entire length of the skystalk and hitting the bottom like a bomb. Then the hose had started to stretch as the other elevators continued moving. Apparently George had cut the power to the

whole chain of them just in time.

She fumed silently. Maybe he'd saved the pump, but none of this would have been necessary if they'd deployed the silica pump in the first place.

Anyway. What to do? Mary considered her options. The elevator itself was probably not worth trying to fix. It was far more important to get the hose deployed, and anyway, to risk damaging it to save one elevator made no sense. Enough others were carrying the weight; they could do without one.

So, the problem was straightforward enough: unhook the clamp from the hose, swivel the elevator car away, and jettison it—making sure that it fell away from the hose, not into it.

Sure, simple: just cross the ten meters of empty space between the cable she'd descended and the parallel cable where the hose was attached, and detach the hose. Then unhook the elevator car and let it drop.

Just.

Mary looked over into that yawning void again and shuddered. She tried to focus on her itches, her discomforts; the slimy feel of her body in its plastic bag of a spacesuit; anything to take her mind off what she was going to have to do. She reached out and ran her fingers lightly over the cable. It felt like a steel rod under her skinsuit fingers, stretched completely taut under the tension of its own weight. She tried not to think about the thousands of kilometers more of it above her.

With a deliberate effort, she

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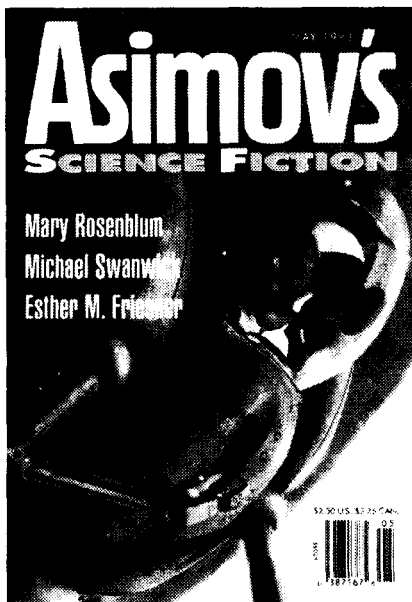
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brought herself back to the job she'd come to do. She took out the telescoping graphite rods for the traverse. Pencil thin, they hardly looked adequate to the task—although they could have supported one of the shuttles. Holding with both hands to try to keep from trembling, she held out one of the rods, pushing the release at the base. It extended slowly, bobbing around in sympathy with the shaking of her hands. She worked it over toward the elevator on the other cable. The amplitude of its swings increased as it extended, finally sweeping back and forth in oscillations several meters across as it reached the elevator on the other side. Frustrated, she tried to hold it still, clenching her hands still more tightly, but the ten meter length of rod waved back and forth like a sapling in a breeze.

Finally, the clasp at the end brushed one of the cage bars and grabbed. She had another one for safety, in case the first didn't latch correctly (she didn't like to dwell on that possibility). She deployed it too. It went more easily, possibly because her anger at the mindless perversity of her equipment had taken her mind off her acrophobia.

Finally, two thin rods stretched from her elevator to the one holding the hose. Mary double checked her safety line and its reel. Then she clipped a carabiner around each rod, making sure each could slide freely. Last, she fastened separate lines from each 'biner to her belt, and one from her belt to her tool kit.

Now the hard part. Mary took a deep breath and leaned backward out

of the elevator, holding tightly to the rods behind her. She let herself down between them, feeling her joints crack with the tension, biting her lip as her wrenched arm protested. She finally swung down underneath, a hand clenched around each rod, a foot also wrapped around each, hanging downward between the two like an ancient sloth slung between two tree branches. She was facing upward deliberately, trying not to think of the abyss below her back.

She forced herself to advance, centimeter by centimeter, moving only one hand or one foot at a time. It did not help her peace of mind that the rods flexed slightly as she moved along them. Finally she felt her helmet brush the other elevator. She lifted herself up and pushed back, trying to turn over as she did so, and trying to use her right arm as little as possible. Finally she grabbed one of the other elevator's cage bars, removed the carabiner lines from the traverse rods and clipped them to the cage, then reeled in her tool kit from the other elevator car.

The empty water tank kept her from climbing inside. Pulling herself up to the top where she could at least stand and hold onto the skystalk for support, she surveyed the situation. The elevator itself would be easy to detach—it had an emergency release for just that purpose—but before she did that she had to unfasten the cargo clamp and swivel the elevator around the cable, so it wouldn't tangle in the hose when it fell. And then, of course, get off of it before releasing it. Details, details, she thought.

Holding onto the cage with her good hand, she leaned outward so she could reach down to the clamp. It had a lever sticking out that would be forced upward automatically when the elevator car reached the bottom; releasing the hose to continue down, pulled by its own weight, while the elevator crossed the junction to ascend the other cable. She stretched with her left hand and pulled on the lever, awkwardly, since she was right-handed.

It didn't move.

She pulled harder, but still nothing happened. Apparently the tension from below was putting enough pressure on the clamp to keep it from releasing smoothly. And she couldn't get enough leverage reaching over the side of the elevator to the clamp—and doing so left-handed to boot.

She hated holding on with her sore arm, but that was what it was going to take. That and a crowbar. She pulled her tool bag up beside her, took out the bar, and leaned back over the edge as far as she dared, trying to find a good purchase for the tool against the stuck clamp. It kept slipping on the rounded lever, and the more she tried the clumsier her fingers became. She felt herself sweating in the skinsuit with her exertions, but the bar finally found solid resistance and with a curse she yanked on it for all she was worth.

Abruptly the latch popped open. The crowbar went flying out of her fingers, pinwheeling off into space, and she felt herself fly up and over backward, breaking her grip on the

cage. She choked a shriek while she scrabbled futilely at the slick surface of the hose, with the mindless panic with which the drowning grasp at straws. Then as she peeled away from the skystalk, her hands went to her safety rope without conscious thought.

She fell leisurely in the low gravity, and bounced gently at the end of her tether perhaps five meters below the elevator, rocking back and forth slowly like a small child on a swing. Panting hard, heart thudding, blood rushing in her ears, she slowly forced herself to calm down, all the while clutching the safety line.

The shock of adrenaline had washed away the fear. She looked around her, then looked *down*, deliberately. The skystalk brushed past her as she swung below the elevator car; on the next pass she reached out and grasped it to steady herself. For a long time she followed the twin cables, with the attached hose paralleling one, down, down, down into the looming bulk of Waterworld below. She thought she could almost see the ballast weight at the end of the stalk, where they'd installed the receiving tank for the water. It was a *long* way down.

Somehow it didn't matter any more. She reeled in the safety line and climbed back atop the elevator car.

The rest was easy. She stuck a small chemical rocket pack on the car so it wouldn't fall back into the stalk when she released it, then unhooked the two graphite traverse rods. She figured she'd just return to the other cable by swinging back on her origi-

nal safety line. The only awkward part was getting the jammed elevator swung around away from the pump hose while she was standing on it, but she finally managed to grasp the stalk with a grippy and wrench the car around, opening and closing just one of the emergency brakes at a time to let it swivel.

Finally it was ready. With a silent prayer, Mary stepped off deliberately into the abyss, floating down in the gentle gravity until the safety line caught her. Then she simply reeled in. Once back in the elevator she'd ridden down in, she triggered the cable release for the defective elevator, and watched as it slowly started to fall; then she savagely stabbed the ignore button. The little chemical rocket she'd stuck on puffed briefly, pushing the falling car farther away from the stalk as it was supposed to.

The jettisoned equipment arced away and downward. She leaned over to watch, but soon she lost sight of it. Even at a mere 0.15 gee, its speed grew rapidly.

She spoke into her radio. "Mary here. All done. Start the hose deployment again. I'll watch from here for a while."

"Roger," George said.

In a few minutes she could see that the hose was moving again, slowly but smoothly. She considered whether she should remain there for the rest of the deployment, but discarded the idea. Her supplies were low, the sanitary facilities in the skinsuits were primitive, and anyway, her arm was starting to swell. She wasn't even sure she'd be able to cross over

to the other cable again if it became necessary.

And in any event, she didn't see any reason that it should be just her responsibility to fix the problems the others' haste had caused. They should never have tried deploying the carbon peripump in the first place. Let Norm come down here if it got stuck again. It would do him good.

"Mary here," she said again. Fatigue and remembered anger roughened her voice. "It's moving all right. Bring me up."

"OK. Good work, Mary," George said. He started to say something else, but she cut him off.

"Over and out."

She had no trouble falling asleep on the ride back up. In fact, it seemed she'd hardly closed her eyes when the alarm woke her. She must have slept the whole thirty hours. Nonetheless, she didn't feel rested. She felt grimy; she itched unmercifully, and her injured arm now throbbed insistently.

All her crewmates were waiting for her. Even Norm floated there by the airlock in the ship's non-rotating cargo bay, his eyes showing grudging respect. George spoke first and offered his hand. "Congratulations," he said simply when she twisted off her helmet.

Something snapped in her at the conciliatory sound of his voice. This situation should never have arisen in the first place, and now he and Ivan and Norm were trying to pretend all was well. Sweetness and light and "well, we're all in this together." Bullshit.

Mary ignored his proffered hand. "No thanks to you, you incompetent coward!" she hissed. "If you had taken a stand earlier, I wouldn't have had to do this!"

George, taken aback, was too tired to be polite. Withdrawing his hand, he said, "The definition of courage, Mary, is 'grace under pressure.'" He turned away, and neither Norm nor Ivan said a word as Mary pulled herself back into the ship.

Still life with scrap, Norm thought, looking at the monitor. The scene opened out on a junkyard, haphazard pieces of torn metal ripped out of anything that could be spared, waiting to provide metal ions to neutralize the acidic water they hoped to collect there. The metal half filled the enormous oblong storage tank fitted into the ballast mass at the base of the stalk. From there, they'd fill the smaller tanks in the elevator cars to carry the water back to the ship.

They hoped.

George looked up at the chronometer. "Any second now," he said unnecessarily. "Then we'll know if *this* worked." He avoided looking at Mary, but she bristled anyway. Norm smiled, glad she had found someone else to direct her hatred toward for a while. Before she could say anything, though, movement on the monitor caught their attention.

Water, charged with acid and oxygen, spurted out of the pulsing tube and splashed into the waiting tank, dribbling down to the waiting scrap. Hydrogen boiled off wherever water met metal, bursting into flame as dissolved oxygen

also fizzed out of the splashing water. The tank was open to space, though; the flame couldn't build up enough pressure to do any damage.

At length the starship's four crew members could see the waterline slowly rising in the tank.

Norm looked to the lowermost monitor, the one showing the view at the pumphead. The ceramic trash-rack on the base of the cable, a cage to keep the native life at bay while they pumped, seemed to be holding. Even so, the carnage outside was straight out of a nightmare: creatures that looked to be all mouth snapping at the cage and at each other until the water turned murky with their blood. Norm hoped nothing in their physiology would provide any more nasty surprises, but he wasn't willing to bet on it. They would have to filter and maybe even vacuum-distill every drop of it before bringing it on board.

Unless, of course, Mary wanted to bathe in it unprocessed. It would almost be worth breaking ship's quarantine to watch her try.

George was as close to achieving harmony as he'd ever been. The very smell of fresh water seemed like perfume. He'd been sitting in full lotus beneath a hot shower for nearly half an hour, and if the recycler didn't quit first he planned to stay there for the rest of the day. He might just stay there for the rest of the trip, all seven years of it.

The idea that he would be a hero at the end of the journey amused him greatly. The colonists who awakened from SloMo would name mountains

after him, maybe even entire continents. Their descendants would learn about the four brave crew members who defied all odds to save the ship, and mothers would name their sons and daughters after them for generations to come. No one would mention the arguments and backbiting that surrounded their heroism, nor the long years of embarrassed animosity they were sure to endure before they reached their goal.

George would trade it all in a moment for the blissful sleep of SloMo, but he knew without asking what the others would say to that. The same thing he would say if one of them asked for the same privilege: they couldn't afford to lose one-fourth of their trained crew members, not with so much reconstruction to do before they reached the colony.

No, he was stuck with them, and they with him, for the rest of eternity. He turned his face upward to let the fresh, soothing water cascade over him while he tried to compose a haiku of suitable irony to fit the situation.

They had, after all, survived.

Thousands of kilometers below the starship, another struggle was underway. The skystalk and the silica peripump had been reeled back into the ship, but the ceramic trashrack at the intake, its fastenings weakened by the incessant battering, had fallen off to sink down into the planet-spanning ocean. Water frothed crimson like a bubbling lung wound as nightmare creatures continued to dash themselves futilely against it, slashing themselves and each other as they attacked the indifferent oxides. The turmoil only increased as time went on, as more and more carnivores sensed the spreading casualties and homed in on the chaos, only to be themselves swept up into it.

The trashrack continued to sink slowly through the frenzied beasts, knocked this way and that like a dust mote drifting in Brownian motion in an afternoon sunbeam.

It tended downward, but it had a long, long way to fall. ■

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HOW FAR THEY ARE

Mark A. Garland

The camp fire burns just feet away
Releasing captured light
Wood embers glowing warm and fierce
Against the chill of night

And round the village night I see
A hundred fires like mine
Faces come and huddle near
A soft, shared moment in time

But as I look up to the skies
There are fires too many to count
A sea of light and warmth up there
A hundred tribes, no doubt

They see our fires, I know they do
And like us they must wonder
How far they are, will we go there?
To the fires that we live under



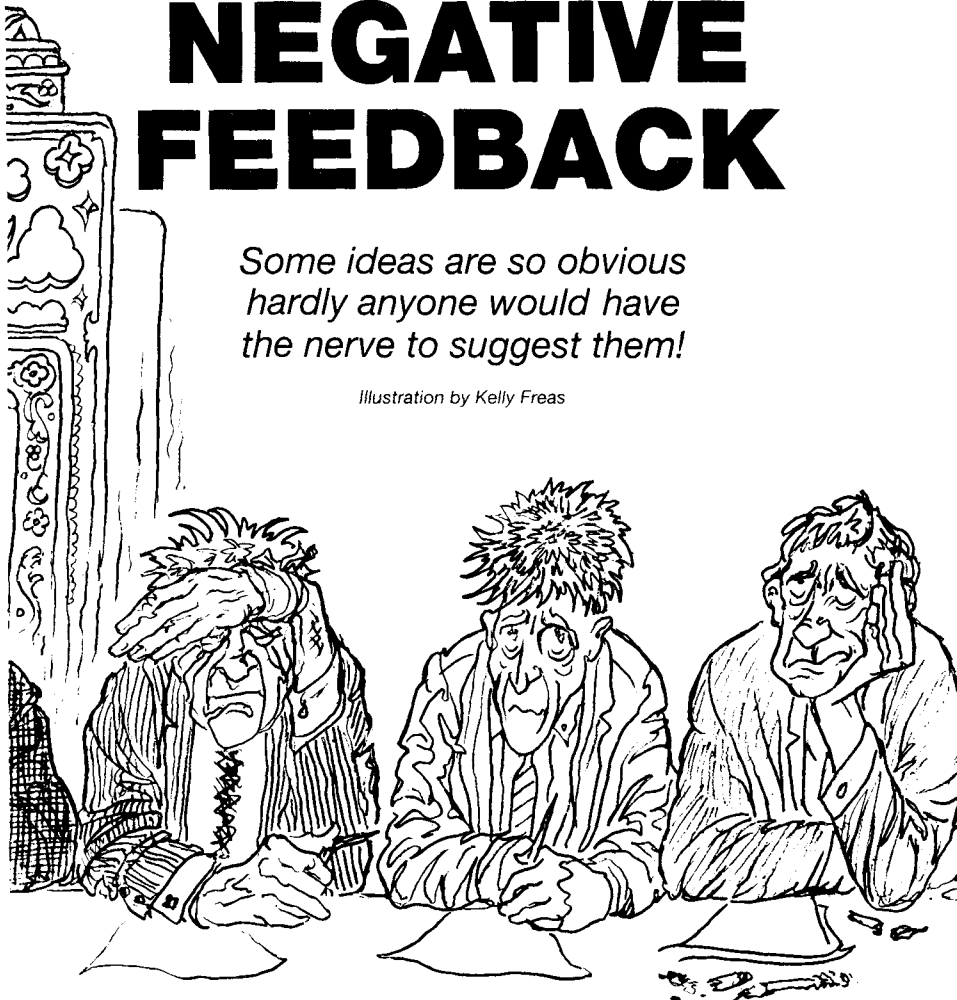
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Christopher Anvil

NEGATIVE FEEDBACK

*Some ideas are so obvious
hardly anyone would have
the nerve to suggest them!*

Illustration by Kelly Freas



KELLY FREAS '93

Julia Ravagger watched her husband, Nelson Ravagger, pay off the deliverymen. Nelson's somewhat predatory profile, the workmen's uneasy glances at the chandelier, marble floor, sunlit conservatory, and other details of the lavishly furnished apartment, taken together with the aggressively prosaic look of the object they had just delivered, all added up to something Julia had felt too often since marrying the famous—or infamous—stock speculator.

"Ummm, Nels—" she said, as the door closed, leaving them alone, "why do I again have this feeling of total perplexity? What, precisely, is that thing?"

Ravagger grinned, creating an unfortunate effect like the surfacing of a shark that is in the process of eating a swimmer. He patted the curving metal top of the object, which was enameled a sickly shade suggestive of dog droppings.

"This, my dear, is a product of the Cartwright Corporation's Fuels Sciences Division. This is the 'business opportunity of a lifetime.' Specifically, this is a 'solid-fuel converter, designed to eliminate the dependence of our nation on foreign oil producers, and thereby return control of our fuel destiny to these shores.'"

She stared. "That's a quote?"

He nodded. "From one of the company's brochures."

"Is it true?"

"If you strain out the high-tech wordage, this is a coal stove. And if it's the kind of coal stove I think it is, it's a bomb."

"Meaning—"

"That after you install it and use it, it won't be long before you'll do almost anything to never have to use it again."

"Then, why are you putting it in our living room?"

He opened a large cardboard box near an elaborately simple white sofa, and pulled out a quivering rectangle of curving black metal—a section of stovepipe not yet locked into a cylinder. He smiled at her.

"Remember the wood-stove craze?"

She glanced covertly at her left wrist, where the burn scar had almost disappeared.

"I couldn't forget that."

Nelson delivered himself of a grisly chuckle.

"No. Me, either. But it was educational."

She glanced up at a small decorative snow scene nearly hidden behind a spray of imitation pussy willows in a tall pearl-colored vase. The snow scene was painted on a circular brass flue cover; the flue openings in the old building had been unplastered and put to use during the time of the Oil Embargo, then thankfully covered up again afterward.

"Well," she said, "but what connection—"

"I'm not sure," said Ravagger, "but we just might have a coal-stove craze next. Cartwright is convinced of it. And as it happens, I'm on their board, and the management has a tiny little flaw that we will have to live through somehow, preferably without bankrupting the company in the process."

* * *

Cyrus Cartwright II, at the head of the long table, winced as Nelson Ravagger settled into his chair near the far end. Beside Cartwright, W. W. Sanson of the Machines Division—former head of Superdee Equipment before its near-bankruptcy and merger with Cartwright—growled, “Ravagger doesn’t look too cheerful.”

“No,” said Cartwright uneasily. “It’s nicer when he’s just bored.”

“Damn it, he’s got that blowtorch look.” Sanson dropped his voice to a murmur. “Remember, you’re the chairman.”

Cartwright squinted at him sideways. “What’s that supposed to mean?”

“Keep him in line. Use your authority.”

“I’m chairman because he doesn’t want to be stuck with the job. If he wanted it, he could take it any time.”

“It’s your name on the door. Remember, your granddad founded the company.”

“Granddad isn’t here. And just incidentally, which one would be worse to get along with, I don’t know.” He glanced at his watch. “Well, time to get started.”

The meeting commenced with boring routine, and proceeded in its accustomed groove until, just as Cartwright had almost forgotten Ravagger, the speculator’s voice reached across the table. This voice had a peculiar resonance, 10 percent of it made up by the construction of Ravagger’s chest and voicebox, and 90 percent by the listeners’ awareness of the number of shares of the company the voice represented.

Ravagger said, “We haven’t heard from the head of our new Fuels Division yet.”

On Cartwright’s left, R. J. Schwenk of the Fuels Sciences Division said cheerfully, “Nothing to report, Mr. Ravagger. No problems. Everything proceeding according to plan.”

Cartwright smiled. “Nels, Schwenkie is a source of real comfort, but demand for our solid-fuel products, as yet, is just starting to perk up.”

On the other side of Cartwright, W. W. Sanson cleared his throat. “As vice-chairman, Mr. Ravagger, I have made it my job to follow the progress of our new Fuels Sciences Division with particular care. Our statistical analysis shows everything on plot.”

“On plot?”

“Everything proceeding according to plan.”

“Meaning what?”

“Aah—meaning that the—ah—that expenses are under control, sales are about where we expected, the market for our products is developing as forecast, we have the appropriate number of dealers signing up. Everything is fine.”

“How about quality?”

Sanson chuckled. “Well, you know our slogan: ‘Quality First, Quality Last—Our Name Is Quality.’”

“OK, you’ve made a special study of the Fuels Division’s products, then?”

“Yes, precisely. Ah, no, wait a minute.”

“Of course, you haven’t had time to do everything.”

A soothing purr was suddenly present in Ravagger’s voice, and Sanson

broke out in a sweat. "What I'm saying is, I've studied the results. That's what counts. I haven't examined each individual product. We have quality control experts, inspectors—I wouldn't intrude that far down the ladder. Our people do their jobs."

Cartwright spoke up hastily. "Nels, if you're thinking of checking up on our workers, the union wouldn't like that."

Ravagger glanced at Sanson. "Which products have you studied, then?"

"Well, as I said, it's the *overall* results that count."

"You haven't examined any of the products?"

Sanson said, "What difference—"

"None *at all*? Even though you're making it your job to follow the division's progress 'with particular care'?"

Cartwright stared down the table at Ravagger, then glanced to his left at R. J. Schwenck.

Schwenck said at once, "That's my job, Mr. Ravagger. I'd be offended if Mr. Sanson felt it necessary to check me up on that."

"Oh, I see." Ravagger looked back at Sanson. "You were scared to check any products for fear Schwenck might get mad at you?"

Sanson blew out his breath. "No, I just trust him to do his job."

"All right. Now, Mr. Schwenck—"

"Yes, Mr. Ravagger."

"You've just heard our vice-chairman say he's not afraid of your taking offense. Naturally, I'm not afraid either. As a matter of fact, I don't think there's anyone here who would hesi-

tate to check on anything because someone might take offense."

"Well, all I meant—" Schwenck hesitated. Before he could find some way around his own comment, Ravagger's words trod on his heels:

"You meant what?"

"Oh, we don't want to interfere further down in the hierarchy, or in each other's territory. It's bad manners. It assumes the other man doesn't do his job. An organization is built on mutual trust."

Ravagger purred, "An excellent defense of your comment, Mr. Schwenck."

Schwenck looked relieved. Sanson looked alarmed.

Ravagger said, "So *you* have checked the products in your own division, then?"

"No, that's what I just—"

Ravagger glanced around. "Then who does check on them? Are we selling stuff we don't know anything about?"

Schwenck said, "As we've said, Mr. Ravagger, we have quality-control inspectors to see to that. Really, you shouldn't criticize what you don't understand."

Ravagger slowly turned his head to look directly at Schwenck. The effect on Schwenck was like having a machine gun take aim at him. Schwenck began to perspire, but kept his mouth shut.

Ravagger said quietly, "In the final analysis, Mr. Schwenck, who is the ultimate authority in this company?"

Schwenck said carefully, "I guess you are, Mr. Ravagger. But that doesn't mean you necessarily under-

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stand it.”

Cartwright said nervously, “Gentlemen—”

Ravagger shook his head. “I’m not the final authority. What I have to do is make you aware who is. And if I have to smash heads or look like a jackass to do it, I will do it anyway. Now, just consider—Who is not in the company, but controls the destiny of the company—any company? Who, because he can make the company succeed or fail, influences the destiny of everyone in it? Who is below the bottom of the organization and above the chief executive at the top? Whose opinion is often ignored or unknown, and whose favor is almost universally courted?”

Schwenck stared. “You can only mean the customer.”

“Right. Now, anyone that important is going to have his interests looked after. And since this is your division, you will look after those interests! What do you mean, the quality-control inspector will do it? The quality-control inspector may check the thickness of metal or the finish on the enamel, but there’s more to satisfying a customer than that! You can’t delegate that job! That job is the most important job you’ve got! It is your personal responsibility to check that those products are right! The only way you can do that is to become a customer yourself! Mr. Chairman, I move that a special allowance be made to Mr. R. J. Schwenck, head of our Fuels Sciences Division, to enable him to immediately purchase, as a customer, one of our Superheat Solid-Fuel Converters—colloquially

known as a ‘stove,’ preferably Model J616 or J617—and report to us at the next meeting on his personal installation and use of this device.”

Madeleine Schwenck looked on in bafflement as her husband paid the deliverymen and eyed the massive bright-red object they had left.

“Richie, what, pray tell, is that?”

Schwenck exhaled carefully.

“It’s a—it’s a stove, Hon.”

“Where are you planning to put it?”

“Right here. Where I had them leave it.”

“There?”

“Remember, we had the wood stove here.”

“Richie, look, we agreed to get rid of the wood stove. And the chainsaw. And the pick-up truck. If you had to get another wood stove—”

“This is not a wood stove.”

“That’s true, you only said it’s a stove. Well, then, what kind of stove is it?”

“It’s a—ah—a solid-fuels converter. Of—h’m—fossil fuels.”

“It’s a what?”

“It’s a coal stove.”

She took a fresh look at him, then at the stove. Then she looked at him again.

He stood frowning at the curving bulk, and asked himself, exactly why did this thing look like a cross between an old-style fire truck and a juke box when the sketches and presentations had shown it as modern and cheerful. A 1930s aura radiated from it, along with a sense of stubborn intractability.

She said carefully, “Richie—”

He said, "Look, Madeleine, this is not necessarily permanent. I—uh—you might look on it as a sort of, well, company homework."

"Rich, please, I don't know what you have in mind, but please remember that I'm a lawyer, and we don't want another of those arguments where we both forget ourselves. And I can feel it starting to build up already. I do pay part of the costs—a good part of the costs—of this house, and I don't mind it, it's fair, but I like to be consulted about what we do and what we don't do. Now—"

He groaned, and told her about the directors' meeting.

"Well," she said, frowning, "I hear it, but I don't understand it. This was the idea of this stock swindler?"

"Hon," said Schwenck, "I may have put it too strong. This guy cuts things pretty close to the line, but it's not that line he cuts close to. He's opinionated, overbearing, and damned tricky; but he's not a swindler."

"Then you're saying he's a stock operator?"

"He sure is. The problem is, for some reason, he's down on this stove; but my whole division is set up to take advantage of an inevitable disruption in the oil industry—this business of upheavals in the Middle East gives us a chance to see what is bound to happen eventually. Now, we are presenting a whole line of these—these solid-fossil-fuel converters, based on products a branch of Superdee Equipment used to make—"

She said, "So what it boils down to is that the biggest shareholder in the

company is on the board of directors, and everybody is afraid of him, and he is making you personally try out one of the products you're planning to sell?"

He said, "Yeah. I guess that is it."

She grinned.

He said aggrievedly, "Damn it, it all makes perfectly good sense! As a country, we're well supplied with coal. Oil, comparatively speaking, is scarce. If there should be a break in the oil supply, the demand for some other source of energy would be fierce. Natural gas can take up part of the slack, but not all. There's going to be a hole there, and something has to fill it. Now, wood stoves produce a lot of smoke; they don't generally burn very long before you have to reload them; there are complicated pollution-control requirements; wood is not a predictable fuel unless you make it into pellets, which costs money; there are environmental objections to the burning of wood on a really large scale; meantime, you have problems storing wood.

"The obvious answer is coal! There are only a comparatively few companies set up to produce coal stoves on anywhere near the basis that we are. And the others, as far as I know, are all asleep at the switch. And we've got our Combuster, a really effective pollution control device, which is a step ahead of everyone else in this business. If something unexpected happened to oil, we could make a mint! And don't tell me nothing could happen! We import a lot of our oil from a place that's a powder keg!"

His wife nodded. "OK, you go

ahead and get it ready. Are the stove-pipes black, like for our wood stove?"

"They're enameled red. A red stove with black pipes—our market research indicated people wouldn't go for that."

"Richie, that is quite a vivid shade of red."

"Yeah, I know. I just noticed that. The color in the sketches looked darker. And the first stoves we made didn't look like this to me. This has an electric effect."

"It jumps back and forth when you look at it."

He swallowed, and said nothing. He had just noticed that the stove was not properly centered in front of the flue opening. It would have to be moved, or the stovepipe would be crooked. And the thing weighed, at a conservative estimate, around four hundred pounds, since the dealer had conned him into getting the big model while he was at it.

His wife sighed.

"I'll put the frozen glop in the microwave. You set up the fossil-fuel converter. That doesn't have an oven in it?"

"No, it's got a HydraFlame Combuster to, among other things, fully burn the gases given off in initial combustion of the solid hydrocarbons."

She said irreverently, "You can't eat that," and went out to the kitchen. He stood, eyes squinted against the electric effect of the red outer metal jacket seen against the pale-green walls of the room. Damn it, how was he going to move this thing?

* * *

W. W. Sanson eyed the trio of blocky-looking objects, and silently asked himself, "These slabs are what we saw the sketches of? What the hell happened?" Aloud, he said, "These are the Cartwright stoves I phoned about?"

The salesman said, "Yes, sir. As a matter of fact, these are a lot like the standard old Superdee coal stoves we used to carry. Only this model has a tricky gimmick in it that's supposed to turn the coal into gas, and burn it up atomically, with nuclear destruction of the pollution."

Sanson got a feeling of chills and fever. With that description, the customer could get nervous and look around for another make.

"H'm, yes," he said, peering into the dark interior.

The salesman said, "Run you about three thousand for the biggest model. You could heat a church with that one."

"I wasn't thinking I needed anything that big." Sanson reminded himself he was, after all, paying for the thing, out of a totally natural irritation with Ravagger. Damn it, he asked himself, why should we go out and buy these things when the market research people had handed in their assessment, and everything was going according to plan? On the other hand, he had already discovered that the design, in reality, had all the appeal of a claw-foot bathtub turned inside-out and stood on end. The price, met in reality, not in a report on paper, gave him a fiercely possessive grip on his checkbook. If it did that to him, it was going to hit other cus-

tomers the same way. And the pale-blue enamel on this batch of stoves was way too light, as if he were looking at several monster chunks of blue cheese.

The salesman was saying, "The middle-sized one is \$2,200. The little one is \$1,600. You can knock half-a-buck or so off all these prices."

Sanson moodily considered that there went all the crafty calculation of laying out a price line-up of \$2998.49, \$2198.59, and \$1598.69.

"I'll take the small one," he said.

The salesman shook his head. "I wouldn't. That spare buoy they stuck in the center to eat the pollution takes too much space. Even in the old Superdees, that little model wouldn't hold a fire overnight unless you damped it way down. Then the fire stays warm, but you freeze. What's the point?"

Sanson stared at him. If the damned thing wouldn't hold a fire overnight, what was the point? Why sell it? He said, "The little Superdee wouldn't hold a fire? Since when?"

"Not if you wanted heat out of it on a cold night, it wouldn't. What you had to do was get up in the middle of the night and load her up again."

Sanson grunted. "You ever tell the company about that?"

"Why waste breath? They were happy. It sold because it was cheap. They were well made, those old Superdees."

"How about this job? What is it for quality?"

"Same as the old Superdees. I'll give them that. They didn't skimp on the metal. —As you'll find when you

come to move it."

Sanson squinted at the salesman. "I'll take the midsize one."

"Good choice. You just give me your address, and we'll send her around. You pick out where you want it put, and get it right the first time. You don't want to have to move it. Now, you're going to want some other stuff to go with it, and we have to work out the details. Where's the flue opening. How much pipe you want? How far from the wall? What—"

Sanson gave a grunt of disgust. He had come in here out of a sense of defiance. After all, what could be wrong? And before the stove had even been delivered, he was already fed up with it. Who approved this guy to be a dealer, anyway?

Cyrus Cartwright II looked thoughtfully at the display. Well, there they were. Of course, there was no sense of urgency, no crowd around, no background of an oil crisis. What stood out now was the dowdy style and the price. But why had the style seemed attractive and the price reasonable in the plans?

A salesman materialized at Cartwright's elbow. "Interested in a stove, sir?"

The board of directors settled grumpily into their seats, and under the wary guidance of Cyrus Cartwright II, who held one hand in his lap while he kept a cautious eye on Ravagger, the meeting proceeded in routine boredom until Cartwright glanced coolly at Schwenck.

"Mr. Schwenck, I believe you have a report on one of our—ah—solid-fuels converters?"

Schwenck, a strip of woven cotton protruding from under the cuff of his left sleeve, growled, "Yes, I do, Mr. Cartwright."

"Perhaps," said Cartwright, his own bandaged right hand, clenched into a fist, coming briefly into view, "you will be kind enough to briefly summarize for us your personal impressions regarding this solid-fuels converter?"

Schwenck clamped his jaw. "Yes, I will."

"Please do," said Cartwright.

Down the table, Ravagger, glancing at Schwenck's wrist and Cartwright's hand, for the first time showed a perceptible facial expression—a quickly suppressed grin.

Schwenck took a deep breath.

"The stove stinks. That's as brief as I can summarize it."

A murmur went around the table. Schwenck said angrily, "If we have another oil shortage, we'll be able to sell these damned things to a lot of people, because it will be either that or freeze to death. But as it stands right now, nobody in his right mind will ever buy a second one."

Cartwright let his breath out in a hiss, and nodded agreeably. "All right. Now perhaps you could give the board, and Mr. Ravagger in particular, since checking on this was his idea, a few of the more specific details."

"The stove," said Schwenck, "to start with, is too heavy; if you need to move it, you're up the creek without a seven-foot crowbar. Even then, it's damned near impossible to insin-

uate the end of the bar between the floor and the lower extension of the sheet-metal outer jacket. Worse yet, there isn't enough room between the inner stove itself, and this enameled metal jacket. If the fire overheats, the jacket can give you a nasty burn. A child could get seared on the part of the jacket near the firepot. Just incidentally, you can see what that means in terms of liability.

"Then, the feed door doesn't open wide enough; when you try to load the stove, the door swings shut on you. The feed door, by the way, is hot. You can get burned on it, too.

"The ash pit is too small, so you are everlastingly carrying out the ash pan, which is likely to be overfull and ready to dump. The ash shaker gets stuck when coal or clinkers jam in the grate, so to get it free you have to push hard on the handle; the handle then gives way all of a sudden and your knuckles slam into the knife-edged frame of the ash door.

"All this is bad enough, but for irritation, the worst is the so-called Com-buster. This chunk of metal takes up space, and gets in the way every time you try to put a shovel of coal in.

"Finally, for good measure, the mount for the optional fan vibrates inside the sheet-metal lining of the stove so that the fan itself rattles and clanks against the cast-iron inner body of the stove. It doesn't always do this. It does it now and then, in certain unpredictable, non-reproducible-at-will conditions of heat and related stress possibly determined by the phases of the Moon.

"In the small model, which I tried

out after using the big one, this list of defects makes the stove frankly worthless. As a matter of fact, we ought to pay the customers to take it off our hands."

Schwenck's recital, delivered with venomous conviction, left a stunned silence. Finally, Grissom, the treasurer, sat up, and said, "Frankness is a virtue, Mr. Schwenck, but hasn't our solid-fuel converter got any good features at all?"

Schwenck looked as if he were thinking earnestly. "If it has one, I can't think of it."

"But wasn't this device your responsibility?"

"It was, Mr. Grissom, and if you are suggesting I ought to be fired for that reason—"

Grissom looked startled. "No. But either you're overstating the criticisms—"

"—You may just be right, at that," said Schwenck.

"—Or we've got a real mess on our hands," said Grissom.

There was a little silence as Grissom, Schwenck, and everybody else in the room, put the pieces of sentences together, to work out who had just said what. Then Schwenck cleared his throat.

"I'm not overstating the objections. I haven't even finished with them. The shape—the style—of this trap is straight out of the Great Depression. The colors—in the catalog, the one that's called 'Cherryapple'—in reality it's an off-shade of red that clashes with more backgrounds than anything I ever saw before. We have succeeded in getting dozens of these

stoves into the hands of the dealers, and the one thing I'm grateful for is that it's dozens and not hundreds."

The silence following Schwenck's last remark was broken by a faint rustling and creaking of chairs as people shifted position uneasily, then Schwenck shook his head.

"Last night I dreamt some fanatical gang blew up half the oil industry in the Middle East, and everyone was buying our stoves. They were selling like hotcakes. The president himself bought one. I woke up in a cold sweat. All I could think of was the shock in store for all these customers."

Halfway down the long table, a pretty woman with dark-blond hair said, "Do our stoves work, Mr. Schwenck?"

Schwenck reminded himself that the name and seeming mildness of this director—descended from a manager of the company named John J. Phyllis—could both be deceptive.

"They work," he said finally, "but to keep warm on a really cold night you pay a small fortune for one of the larger versions, or get up twice to reload the little one."

"Does what you've mentioned conclude the list of defects? Or are there more?"

Schwenck opened his mouth, but didn't get a chance to speak. Sanson, apparently out of an impulse to protect his subordinate, put in, "You have to remember, Miss Leslie, it's the small model Mr. Schwenck is really unhappy with."

The pretty blonde looked at Sanson coolly.

Sanson looked briefly puzzled, then winced. "Excuse me. I mean, Miss Phyllis."

She glanced back at Schwenck, who said, "It doesn't conclude the list of defects, though it's all I can think of at the moment. It's all but impossible to remember all the things that are wrong with this stove."

"But does it work?"

"It does give heat."

"And that is what it is supposed to do, isn't it?"

"Yes, but the problem is the way it does it. It's a very wearing way to try to stay warm."

"But if there were a fuel shortage, it would help solve the problem, wouldn't it?"

"Yes, it would. But if we ever want to sell two of these stoves to the same customer, or to sell one by word of mouth to anyone, we have a lot of improvements to make."

"What are you doing to correct the problem?"

"I've got everyone I can working on it. It looks to me as if we need a complete redesign."

"And how long will that take?"

"If things don't go just right, it could take a year-and-a-half. I never knew things to go just right yet."

"When this 'solid-fuel converter' was first suggested as a fit source of investment for us," said Leslie Phyllis sweetly, "it seems to me we were told it already had a long successful history behind it."

Schwenck opened his mouth, and shut it again without saying anything. Involuntarily, he glanced at Sanson.

Sanson cleared his throat. "That

was my responsibility, Miss Phyllis."

She turned to look at Sanson.

Sanson said, "At Superdee, we sold a lot of these stoves, including the small model. So far as I know, no one ever complained."

"Then you disagree with Mr. Schwenck?"

"I wish I did. No, he's right. This stove is a real bomb, and that's leaning over backwards to be polite."

"But it's the same stove you sold before, isn't it?"

"In most ways, yes, it is."

"Well, how can that be?"

"Two things have changed. We've added the Combuster. That takes up space, and gets in the way, particularly in the small model. Then, too, we're planning to sell these stoves in great numbers, to new customers—customers used to oil heat. At Superdee, we sold them to rural families who had been using wood or coal stoves for a long time. These present models are still solid, well built, long-lasting stoves that will do a good heating job for people who need a reliable coal stove, and are used to them—or for people who are upgrading from wood stoves. For someone used to an oil burner, it's a different matter entirely."

"Why?"

"For someone who learned to drive in a car with a stick shift, changing gears is no problem. It's a different matter if you've always driven an automatic, and suddenly you've got to drive a stick shift. The market we are aiming these stoves at now will respond to them the same way. These are people used to automatic

heat—to thermostats.”

“Yes . . . but if there’s an actual fuel emergency?”

“People will buy them if they have to. But everyone will make stoves once it’s clear there’s a need. What we can naturally expect is a big demand, which we can’t possibly keep up with. Then, after we increase production, demand for our models will drop like a rock—because word will get around about the defects in this stove. Then our competitors will skim the cream.”

Cartwright said, “I have to agree with Mr. Sanson and Mr. Schwenck. The fact remains, we at least have a stove—which is more than most of our potential competitors can say. And now we see what the problems are. If we can clean up the problems, we’ll have the advantage we’ve been aiming at since the beginning.”

“Does the combuster work?”

Cartwright nodded, and glanced at Schwenck.

Schwenck said, “It works, but the fifteenth time you bang into that brace when you put in a shovel of coal—”

“But, look here, Mr. Schwenck, didn’t you know where the combuster was going to be when you authorized production? How is it that it ended up in the wrong place?”

“I’ve asked myself the same question. In the original computer design, we allowed room for the shovel to enter the feed-door opening and deposit the coal in the combustion zone. We even checked out the measurements on a full-scale hand-assembled model to be sure. And it is possi-

ble, if you have someone open the door and hold it open, to carefully put a normal-sized fire shovel into the firebox and not bang into anything.”

“Then what’s the problem?”

“There’s a difference between loading the stove in a laboratory-type setting, and actually using it. This Combuster is held in place by braces—three of them reach down into the firebox. It’s perfectly possible to miss all three. But the feed door tends to swing shut; to avoid the door, you move the shovel a little, and then you hit the left-hand brace. That never happened when we checked it out, because we were crowded around the stove, and someone held the door open.”

Leslie Phyllis looked at him thoughtfully. “But now that you’re actually using it, you run into these difficulties?”

Schwenck nodded.

“Are there any further defects?”

Sanson shook his head. “Mr. Schwenck hasn’t yet mentioned one of the worst. For years, at Superdee, we routinely put a black protective coating on the body of the stove inside the enameled outer shell, to protect the metal from rust, and improve its looks.” He gave a little laugh.

Schwenck looked at Sanson. “I never heard a complaint.”

“No,” said Sanson aggrievedly. “Me either.”

“Now what?” said Leslie Phyllis.

Cartwright said sparsely, “Fumes. Every time the fire gets hot, some of this protective coating boils off.”

Grissom, the treasurer, glanced from Sanson to Schwenck. “Well, you

weren't the only people to use that coating. I bought a wood stove during the fuel shortage, and the first good fire I lit the stuff boiled off in clouds. It stank up the house, and a fine oily dust settled over everything."

Sanson and Schwenck studied the tabletop. Cartwright looked mad, but kept his mouth shut. Down the table, Nelson Ravagger was elaborately expressionless.

Cartwright sucked in a deep breath. "Well, we now know first-hand exactly what our customers are going to run into. We have to clean up these things." He glanced at Schwenck.

"We're counting on you, Schwenckie."

Schwenck settled visibly under the burden, then nodded.

"There's got to be some way around all these problems. If we just have time enough, we'll find it."

Nelson Ravagger was wearing a blue bathrobe with an elaborately patterned red-clawed dragon on it as he opened his front door some twenty-two months later, picked up the Sunday paper, and padded back to the bedroom with it.

Julia Ravagger yawned as her husband settled into his side of the bed, noisily unfolded the first section of the paper, then gave a sharp grunt, as if he had been hit.

She sat up. "What's wrong?"

He passed over the front page, where big black headlines screamed:

BLASTS IN MIDEAST

PIPELINES HIT

LOSSES HEAVY

Julia Ravagger stared at the paper,

then handed it back without a word to her husband.

He read aloud, "... It is believed that the powerful weapons used were originally smuggled out of the Soviet Union at the time of its political collapse... nightmare of the U. S. Administration come true... terrorists reportedly demanded five hundred billion dollars not to use atomic bombs against the refineries and pumping stations... authorities are now convinced that atomic weapons have not in fact yet been used although... at 2:00 A.M. the first heavy rocket attacks were made, cutting oil shipments, and creating fires which rival in intensity the conflagration in Kuwait at the end of the Gulf War. More explosions soon followed... A quick-reaction strike-force is already on the scene, and troops are in motion halfway around the world. But nothing can now be done to prevent serious energy shortages. It is not known at the present time if..."

Ravagger took a second careful look at the papers, then reached around and plugged in the phone that sat on the night table. He dialed a number.

Madeleine Schwenck's voice replied sleepily. "Hello?"

"Nelson Ravagger, Mrs. Schwenck. May I speak to your husband?"

R. J. Schwenck sounded even sleepier than his wife. "No, no, Mr. Ravagger, I haven't seen the paper yet. What's up?"

Ravagger methodically read the headlines, and as Schwenck exclaimed in horror, Ravagger read aloud the first part of the article,

which reduced Schwenck to silence. Ravagger said, "How close to ready is our improved coal heater?"

"We tested it last week at the lab. I've been using one in my office for several weeks. Mr. Sanson has had an early version at home since around New Year's. The small model can't cut it till we find some way to shrink the Combuster, but the other two are not bad at all. Compared to the first version, they're straight from heaven."

"You see what we're going to have to do."

"We've already got a moderate production going. There's no reason we can't step it up. By next fall we can flood the market with this improved version. I'll call Mr. Sanson right away."

"Good. I'll get hold of Cartwright."

Julia Ravagger had turned on the bedside clock-radio, where an announcer was saying "... Inevitable that gasoline supplies will be affected. Heating oil prices will skyrocket. By next winter, a severe worldwide fuel shortage will be in place. There is already no way to prevent the most severe hardships in the depths of the coming winter. ..."

She glanced at Nelson Ravagger, who was hunting through the phone book. She said, "You actually have an improved version of that monstrosity in the living room?"

"Yes. That monstrosity's just a prototype. The problem was, they didn't know it."

Ravagger dialed a number.

Julia Ravagger said, "Was that the 'tiny little flaw' you said the management had?"

"The flaw was the company actually didn't have any negative feedback worth mentioning on some of its products, including that stove."

"Negative—." Oh, yes, negative feedback is the signal that tells which way a robot arm is off-course as it reaches out to take hold of something? A correction factor that puts things back on course."

"Right. And one way to get useful negative feedback is to have the exact people who can end a problem be the ones to get kicked in the face by it."

There was a click in the receiver, and Cartwright's voice said, "That you, Nels?"

"Right here."

"Thought it was you. I've heard, and I'm on the way in."

"Good work." Ravagger hung up the phone, and warily unfolded the paper. As he settled back, Julia Ravagger was favored with a fresh view of his combative profile. As one of her old friends had said on hearing of her marriage, "Well, Jule, now you've really done it. How are you going to domesticate that throwback to the Age of the Robber Barons?"

Julia glanced at the screaming headlines, and exhaled carefully.

Considering what the world was like, possibly the country could use a robber baron or two. ■

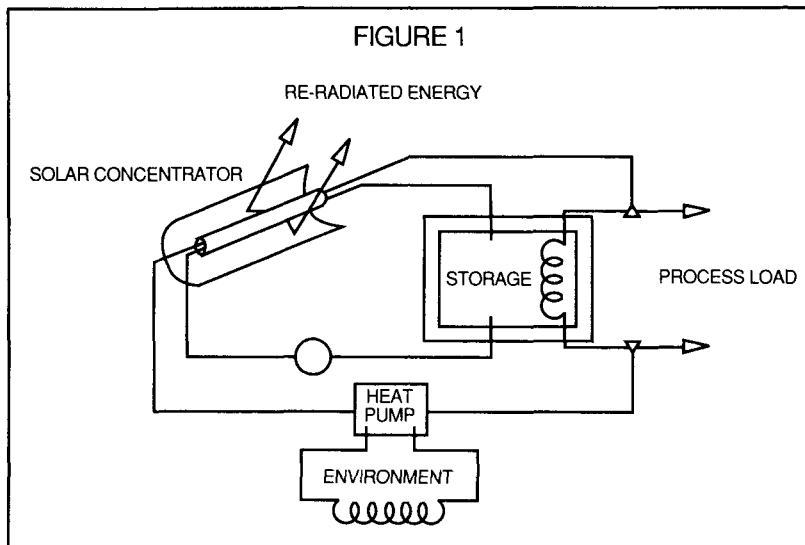
T. E. Larsen

FROM FICTION TO FACT: A TECHNOLOGY POSTSCRIPT TO “ONLY THE WEATHERMAN”

In the September 1990 *Analog* novelette “Only the Weatherman,” author Doug Larsen provided characters and life for a story based on Stefan-Boltzmann equations relating to the intensity of blackbody radiation as a function of its temperature. Jim and Joanie, the characters in the story, assembled an apparatus for enhancing re-radiation of excess heat to space. The idea, thought up by Joanie, involved extracting heat energy from the environment and raising its temperature using an outside energy source. The purpose was not only to increase the intensity of re-radiation, but also to shift it toward shorter wavelengths, away from the CO₂ emission bands starting at about 12 micrometers. Because hydroelectric power was available, they were able

to leverage the Stefan-Boltzmann 4th power radiation advantage without adding significant local heating, and ultimately demonstrated that their apparatus could alter local atmospheric conditions.

Without a doubt, the author knew that their process was thermodynamically break-even on a global basis. However, he also had the knowledge of an extension of the concept now covered by U.S. Patent 5,177,927, which describes an apparatus similar to that used in the “Weatherman” story. Shown schematically in Figure 1, it utilizes a technique that drives the thermodynamic processes strongly in favor of a net gain in radiated energy as compared to what would occur without its use. The key factor is that of inducing the neces-



sary higher radiating body temperatures by using energy that is terrestrially-based, but at the same time is extra-environmental.

To illustrate the concept, we can use the radiation from one square meter of Earth's surface as a base value, and compare this to the area of surfaces at other temperatures emitting the same quantity of heat. For the first comparison we'll use a near-blackbody radiator and raise its temperature to elevated levels using conventional energy sources, much the same as was done by Jim and Joanie. The second comparison will use a similar apparatus, but the energy for elevating its surface temperature will be derived from an extra-environmental source, as taught by the subject patent. For both comparisons we assume that a system is constructed

similar to that in the patent description, with the objective of increasing efficiency of radiation to outer space. If the net amount of radiation to outer space from the apparatus comprising the system is significantly greater on a unit radiating basis than that from the surface of the Earth, then the objective will have been achieved.

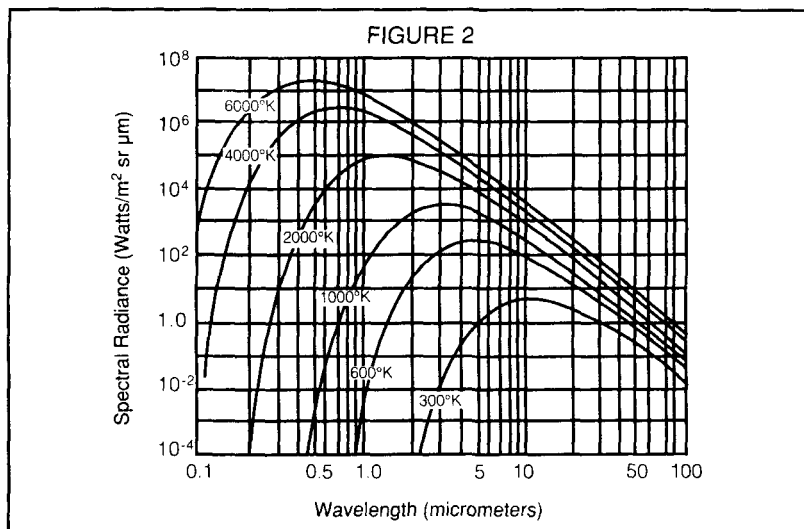
The total amount of energy radiated from a blackbody surface is given by the Stefan-Boltzmann law. Assuming a surface temperature of about 30°C (to reflect the possibility that things on Earth might be overheated), this can be expressed as: $R_t = kT^4$, where $k = 5.670 \times 10^{-8}$, $T = 300^\circ\text{K}$ (27°C), and R_t is total energy. It can be graphically determined that the portion of radiation lying within atmospheric windows and emitted from a 300°K body to

outer space is about 33% of the total calculated using this equation. Corrected for variations in atmospheric transmittance over the wavelengths between 8 and 13 micrometers, and also for the fact that Earth does not emit as a blackbody, the net radiating efficiency from Earth to space comes out at about 22%. And so, the "base quantity" of radiation directly to outer space from a 300°K portion of the Earth's surface is: $R_{a300} = 5.670 \times 10^{-8} \times 300^4 \times 0.22 = \text{about } 100 \text{ watts/m}^2$.

If the temperature of the radiating body was raised from 300°K to 600°K, for example, the value of R_i would be increased about 16 times for a radiating surface area of 1 m². Or, in other words, the surface area of a 600°K body required to emit 100 watts is only 1/16th as large as that required at the lower temperature.

This gets to the heart of Jim and Joanie's system, so let's explore it further. Assume that an amount of heat equal to the net radiation from 1 m² of Earth's surface is extracted from the environment using a heat pump system. Referring to pertinent refrigeration curves and calculations, it can be determined that extracting the calculated 100 watts "base quantity" of heat from the environment would require a certain weight of heat transfer fluid. Raising that quantity of fluid to 600°K, with the objective of improving radiation efficiency, would require about 2.6 kilowatts, an amount of heat that would also be released if the fluid were appropriately contained and cooled to its original temperature.

The curves of Figure 2, obtained by use of the Stefan-Boltzmann equation, show the level of heat released by



radiation for a range of body temperatures as a function of wavelength. The total heat radiated from a surface which is cooling from an elevated temperature by radiation to outer space is represented by the area under the curves. For a body at 600°K, this has been graphically determined to be about 2.2 kilowatts after taking into account the atmospheric factors mentioned above. With a calculated total of 2.6 kilowatts to be dissipated, and an estimated radiating capability of 2.2 kilowatts, it can be seen that nothing is gained by the exercise when the required higher temperatures are generated from environmental sources. The 4th power advantage is more than offset by the environmental energy expended to achieve the higher temperatures.

With no global gain from using the first energy source, let's see what Jim and Joanie would have achieved if their re-radiation mechanism was constructed as described in the referenced patent. Instead of using environmental energy as in the first comparison, the heat transfer fluid can be raised in temperature using fluid previously gathered by solar concentrators and stored at high temperature in insulated containers. This stored energy is a key element in the technique, because it is available for use but has not yet been released to the environment and become part of the global heat balance equation. It is extra-environmental, low entropy heat.

Assume that solar concentrators have been used to gather heat radiation and store its energy at a temperature of about 700°K. Since it has low

entropy, it is of high quality and thus capable of doing work. As mentioned above, the energy to raise the heat transfer fluid to 600°K can be obtained for the second comparison by extracting and using a portion of this stored solar heat. If not used for this purpose, the extracted solar energy could alternatively be applied to perform other work. While this would normally be the case, it would ultimately enter the environment and release about 2.6 kilowatts. When applied as energy for enhancing re-radiation, however, not only is each base quantity of environmental heat radiated to outer space at an atmospheric efficiency higher than would normally be the case, but this additional quantity of diverted solar heat is prevented from entering an already (presumably) overheated environment. To dissipate these 2.6 kilowatts by radiation to outer space, if they were allowed to enter the environment and cool to the average environmental temperature, would require about 26 m² of Earth's surface area. However, since surfaces maintained at the higher temperatures cited above will dissipate an estimated 2.2 kilowatts per square meter of radiating surface, only about 1.2 square meters of surface will suffice to dispose of the referenced 2.6 kilowatts, and a re-radiation leverage of about 22 is achieved utilizing the extra-environmental energy.

An important aspect of the methods described in the subject patent, and not explored by Joanie and Jim, is that incoming radiation can be directly re-radiated on a real time basis

through the de-focusing technique described therein, and this can be carried out simultaneously with the re-radiation of stored heat, using the same mechanism. Thus, all radiation for a given day that falls on the apparatus described in the patent can be directly rejected to outer space. In addition, the stored heat collected on previous days (extra-environmental energy) can be re-radiated at much greater efficiency than would be the case if it were allowed to enter the environment and cool to the average temperature of the Earth.

Extensively deploying solar concentrating apparatus for collection of energy would in itself reduce the need for fossil fuels and the emissions accompanying their use. Furthermore, if the solar apparatus is properly equipped for re-radiation of en-

ergy, the dilemma created by uncertainty over global warming is automatically overcome. When and if it occurs, the deployed system could combat its effects as needed. If it does not occur, the system is still justified on its own merits as a distributed energy source. In this latter regard, the apparatus described in the patent is similar to structures currently utilized for collection of solar energy. One major difference, however, is that an apparatus designed for both the collection of solar energy and the re-radiation of terrestrial energy must be capable of reflecting radiation wavelengths not only in the visible spectrum but extending into the infrared to about 13 micrometers. Concentrating collectors presently in use are limited to wavelengths below 2 micrometers. ■

It's been established that melting of glacial ice, as it receded from the North American continent some 11,000 years ago, produced an enormous lake in central Canada which we know as Lake Agassiz. Formed in a bedrock depression, it attained an average depth of more than 125 feet, and covered an area of 175,000 square miles. Evidence indicates that the lake initially drained by overflow to the south, down the Mississippi River. However, continued retreat of the ice eventually opened a channel to the east, and released most of the lake water down the St. Lawrence River into the North Atlantic. This sudden influx of water into the ocean was sufficient in volume to alter the

salinity of adjoining waters, and thus to affect its density.

The relevance of this to our present situation can be understood by examination of ocean currents which are responsible for transport of heat from southern to northern latitudes in the northern hemisphere. Known as the "Atlantic conveyor," warm ocean water is transported north at moderate depths until it encounters much colder, more dense water in the region of Iceland. It then rises to the surface, releasing enormous quantities of heat that significantly contributes to the relatively mild climate of Northern Europe. The water, thus cooled, is now sufficiently dense to plunge downward, and close the

circulation loop by flowing southward along the deep ocean floor.

In an article entitled "What Drives Glacial Cycles?"¹, a theory is propounded that drainage of Lake Agassiz diluted Atlantic conveyor waters at their deep-water formation site by a sufficient amount to disrupt the continuity of flow. Fresh water being less dense than salt water, the diluted surface waters were reduced in weight to the point that flow to the ocean depths was no longer possible, and the Atlantic conveyor shut down. In a very short period of time, geologically speaking, Northern Europe was deprived of a major source of heat and froze over.

The current debate regarding con-

sequences of global warming, when and if it occurs, usually assumes gradual changes to which society could adapt with time. The relevance of the above observations to that debate would seem obvious. If temperature increases due to global warming should occur which are sufficient to melt polar ice and raise ocean levels, as some have predicted, it follows that at least as much dilution of the Atlantic conveyor deep-water formation sites would occur as was caused by drainage of Lake Agassiz 11,000 years ago. Rather than gradual shifts in climatic conditions, it seems more likely that increased global warming could produce a major shift over a relatively short period. Latitudes close to the equator would lose a major heat sink, and Northern Europe could be once again covered with ice.

¹Wallace S. Broecker, George H. Denton, "What Drives Glacial Cycles?" *Scientific American*, Jan. 1990

About the Author

Mr. Larsen is an engineer and inventor, presently head of Advanced Innovation, Inc. of Minneapolis. He has a history of involvement in the solar energy field, beginning as a major investor in Suntec Systems of St. Paul, MN, a now defunct manufacturer of line concentrating solar collectors. Confident that solar energy will eventually have its day, he is presently an investor and is a director of Industrial Solar Technology, located in Denver.

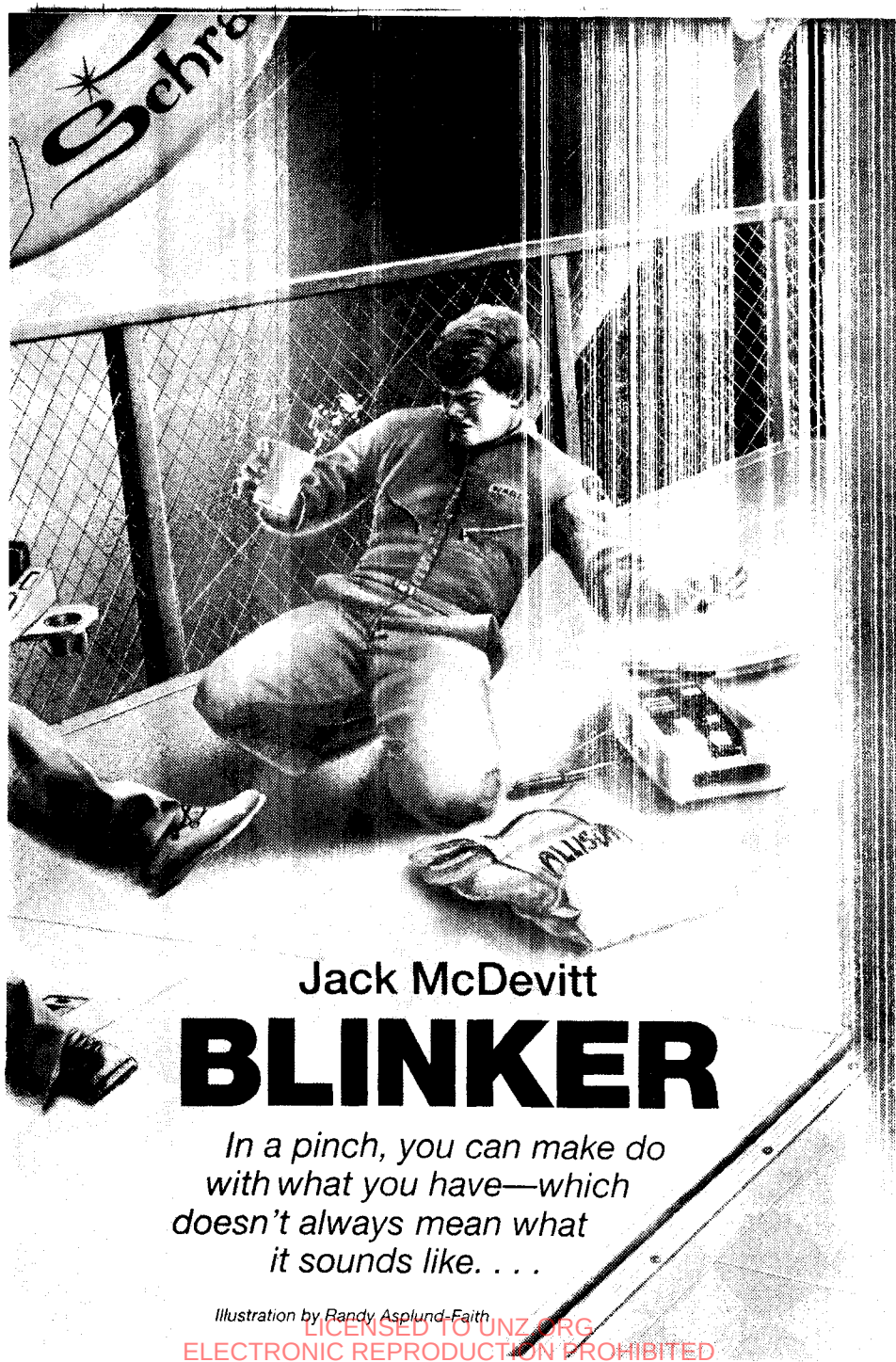
Mr. Larsen served as technical director for Honeywell in Europe from 1962 to 1969, during which time he developed an interest in international business and world affairs. He later

founded Detector Electronics Corp., a high-tech Minneapolis company with foreign sales activities that won them the Presidents E and E-Star awards for excellence in exporting. In 1988 Larsen founded Advanced Innovation, which he describes as a "hands on" venture capital operation. Using his own funds and expertise, he has nurtured and guided several companies into diverse fields ranging from explosion suppression to power switching apparatus.

Larsen has infrequently been the source of technical ideas adopted by his son, Doug, for use as the basis of science fiction stories, some of which have appeared in *Analog*.



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Jack McDevitt

BLINKER

*In a pinch, you can make do
with what you have—which
doesn't always mean what
it sounds like. . . .*

Illustration by Randy Asplund-Faith

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The second shock hit as Ward stepped off the ladder onto lunar rock.

"Look out!" Amy's startled voice rang in his earphones.

The ground swayed. Dust rose.

He looked up at her.

"Twice in one day," she said. "Is it always like this?"

"Didn't used to be." Ward had lived here almost five years before they'd automated everything and moved everyone back to Moonbase. Or Earth. He didn't think there'd been more than a dozen quakes during the whole time.

"Glad to hear it. Maybe we need to do a seismic survey."

"I hate to put it this way, but it's *your* problem now." As of noon, Amy Quinn had become the new director of the NASA/Smithsonian Darkside Observatory. Ward was officially on his way home.

The ground steadied.

The observatory, a dome and a smaller saddle-shaped building and a field of eighty-six radio telescopes on tracks, had been humanity's most remote penetration, unless you counted computers and robots. And Ward never counted them.

It was located on the far side of the Moon just south of Moscoviensse. A place its one-time inhabitants had cheerfully called World's End.

The complex lay atop a group of low gray hills. The dome was sixty-one meters high, roughly fourteen stories. The outer lens of the magnificent twenty-seven meter multiple-mirror Schramm reflector penetrated its polished surface, black and

smooth. The Schramm was the biggest optical telescope in existence.

The saddle-shaped building had provided living quarters and technical support for the crew and staff of seven. This was the annex, and it was connected with the dome by a ground level passageway. Starlight shone through the passageway's walls.

Solar collectors crowded the roof of the annex. A laserburst antenna turned slowly on its axis, tracking a comsat. Its windows were dark and empty.

Beyond, the tracked telescopes pointed their dishes toward the radio galaxy Perseus Alpha.

Home.

Amy climbed cautiously down the ladder and dropped to the ground. "It feels *depressing*," she said. "You actually *lived* out here?"

"Five years."

Her expression registered sympathy, admiration, and astonishment.

"It was a good experience," Ward said. "We had top people, and we were in on everything that was happening." Moreover they had all liked one another, and they were away from the bureaucratic pressures and monumental egos one normally found in terrestrial facilities. Ward had never understood how it happened that so exemplary a staff would be assembled at one site: Bentwood and Kramer and both the Andersons and Mau-Tai and Ali. And when they retired or moved on, the replacements also seemed extraordinary: people with talent and a sense of humor and a willingness to jump in and

do any kind of job.

"I'm glad to hear it," she said, doubtfully.

The first quake, eight hours earlier, had hit while she and Ward were admiring the sharp clarity of the image of the irregular galaxy NGC-1198. One of the technicians was pointing out a Cepheid variable when the Cepheid abruptly faded back into the river of light, and the river dimmed to a smudge.

Monitors indicated almost no damage to the complex, save for the Allison amplifier, which was ironically the guts of the Schramm.

Ordinarily, Ward would simply have sent out a tech to fix the problem. But he wanted to see World's End one more time before he went back to Earth. Furthermore, he told himself, Amy should be exposed to the facility she was about to direct.

He carried the replacement amplifier in a canvas bag slung over his right shoulder. It bounced against his side as he walked uphill. It was good to be back. The air in his helmet was cool and fresh. It moved across his face, tasting of ozone, as if there had just been a thunderstorm. The suit was bulky, but not burdensome in the light gravity.

The complex loomed ahead dark and vaguely gothic in the starlight. "It has a lot of atmosphere," Ward said.

She chuckled. "You got that right." And it may have been that something in his voice caught at her. "You're really attached to this place, aren't you?"

He shrugged. "Yeah," he said. "I guess so. It's the last outpost." He

slowed down for her, mindful that she was not used to the gravity.

"How do you mean?"

"Everything's unmanned now. The Titan mission will be unmanned. Mars is unmanned. They even pulled us out of here."

"But, Edgar, there's no point keeping anyone here now. You can sit back at Moonbase and run things just as easily."

"I know. And there's no point sending people to Titan either." *But what's the point of going if we don't really go?*

They crunched up a mild incline, and stopped in front of the annex. Ward raised a remote. Lights blinked on inside. He touched it again, and the connecting passageway to the dome lit up. The airlock door swung open.

"I envy you," he said. "But at the same time, I'm glad I'm leaving."

They passed into the lock, and he started the cycle.

"You're right," she said. "We are entering an exciting period."

He nodded. They were closing in finally on the great questions. Was the Universe open or closed? Flat? Or twisted? What had happened to the quantum energy of the original vacuum? What was the nature of the force that had called the cosmos into being? Why did the galaxies recede only at discrete velocities? In better days, he and his small band of colleagues, isolated on the far side of the Moon, had enjoyed the illusion that *they* were at the front of the wave, that they were in fact virtually alone in running the Universe to

ground, inhibited only by the demanding voices from Greenwich, Harvard, and Sydney.

She gazed at him thoughtfully. "What are your plans, Edgar?"

"CalTech. I'll be working with Lasker."

"You don't sound all that enthusiastic."

"Oh, it's a good situation." Maybe there was a sense that his life had peaked and started downhill. Maybe it had to do with returning to the scratching and clawing of workaday cosmology. Maybe he was just tired.

The annex was more sterile than he remembered it: a large two-story open well not unlike a garage. Offices ringed the upper level. A rover, a crane, and a pair of motorized dollies were parked in their stalls. Cabinets and cases and empty pallets lined the walls. Life Support was off to their right.

Ward struggled out of his pressure suit and hung it in the rack. The temperature, which was usually maintained a few degrees above freezing to protect the equipment, had been raised to a balmy sixty-eight.

Amy was a slender woman, in all senses of the word. On the Moon, she weighed maybe seventeen pounds. She appeared to be approaching fifty, said she'd trampled that figure long ago. Her eyes were green and animated. There was something of the aristocrat about her: he suspected she had been born into money, had gone to the best schools, and was accustomed to being treated with deference. He grinned at the thought of the demands, whines, and threats she

would have to deal with in parceling out time on the big scope.

He pointed to a heavy door in the rear of the building. "Back there," he said, "are the old living quarters. Room for eighteen people. Although we never had that many. But we did get a lot of visitors." At one time, World's End had been the lunar showcase. VIPs always swung by the great observatory, to look through the eyepiece, and drink coffee with the recluses.

The passageway to the dome connected on their left. Ward touched a presspad. Circuits bleeped and sighed. The door retracted into the overhead. He heard her catch her breath: the walls were transparent and seemed to open out into the moonscape. The lighting was soft, and the shadows of the rocks blended with those of the furnishings. Padded chairs and worktables were neatly arranged in clusters. Several wooden tubs were set off to one side. "We had a lot of greenery here," he said. At one time this lounge area had been filled with blossoms and potted trees. One of the tables was still set for poker, which had been the game of choice.

They stepped through, and the lock sealed behind them.

He dimmed the lights, and they might have been standing on the naked surface. The stars blazed overhead. It was a stunning effect.

Amy stared out at the sky. "It's gorgeous," she said.

"Like nowhere else."

He opened up the airlock at the far end, and they strolled into the dome.

Ward had always been proud to show off the Schramm. It tended to awe the duller of visitors. It was the instrument of Jhard'ahl and Pierce and Brandenburg. "A lot of history has been made here," he said.

The telescope dwarfed them. It was as big as a jumbo jet. But it was far lovelier. Its cream-colored casing was smooth and tapered and exquisitely balanced in a network of struts and braces and beams. It was enormous, and its power and beauty stirred his soul. *Magnificent.*

The observer's cage was mounted on the side of the telescope, seven stories overhead. It was accessible from one of the two turrets that supported the instrument. Deep within the reflector, tiny motors whirled. The Schramm was moving, the entire dome was moving, adjusting to the motion of the Moon, tracking a target. Ward took out a notebook. He said, "4C-1651."

"What's so funny?"

"It's tracking Keeler's quasar. Do you *know* Keeler? He'll be one of your biggest problems. At this moment he's getting a screwed-up image. He's not happy, and he's probably on the circuit screaming at Ops."

"Well, I suppose he has reason to be upset."

"He upsets at a low level." Ward was about to launch into a Keeler story when the third shock hit.

A ripple rolled through the floor, and the lights dipped. He tightened his grip on the amplifier. Before he was quite certain what had happened, the sensation was gone. The internal motors seemed to kick up a notch.

That might mean the telescope had been jarred out of position, and they were making adjustments.

"That was a big one," said Amy. She glanced around uncertainly. "Are we OK?"

"I think so."

The observer's cage suddenly looked dangerously high. Not a place to be during a quake. *Damn.* He wondered whether any more jolts were coming. It almost seemed as if the old place was irritated with him.

He went into the operations office, and activated the commlink. "Moonbase," he said, "this is Ward."

"Go ahead, Edgar." Bil Clayton's voice. The duty officer.

"We are going offline with the Schramm."

"That's a roger. How long do you expect to be down?"

He looked at Amy. "Hard to say." He might need only to reset the present unit. An hour or so. On the other hand, the amplifier could be wedged in tight. "Could be a few hours," he said. That would be more than enough time.

"Roger. We copy."

He signed off.

The Schramm coded its images, which were then transmitted by laserburst to the sensors of a comsat. The comsat converted the signal to radio, and broadcast to Moonbase, which handled relay to Earth. Now Ward broke that link.

He slung the canvas bag with the amplifier over his shoulder. "You want to go up?"

"Of course," she said.

* * *

The elevator was a small hatchwire box, capable of carrying four people. It creaked as it ascended through the turret.

Ward loved the big observatories, these gleaming interfaces between men and eternity. They were necessarily set high in remote places, where the wind blew and the stars murmured. This one, of course, was the champ.

He had become a cosmologist because astronomy seemed dull. He had never been much interested in the mechanics of stars, or the chemical properties of the planets. It didn't matter to him that there were volcanoes on Io or nitrogen on Neptune. Nor did he care how the Sun cooked its helium.

Give him the beginning and end of the Universe. Edgar Ward on the track of the Big Bang. Yes, indeed. The Schramm was less a window on the galaxies than on creation.

They rose toward the telescope housing.

By God, this was the way to live.

Ward remembered how it had been when they'd opened the observatory. They'd invited the top people in the field to attend, but few had actually come. The shuttle flight scared most of them off. But Swifthawk had come with Kitt Peak, Yamoto from Princeton, Stevens from Hamburg, Coddie from Greenwich. Haswell and Corrigan from Fermi had received invitations, but they'd declined, thank you very much, Haswell claiming a stiff work load, Corrigan a bad back. Then they'd changed their minds and come. Ward had admired that. He'd

been at Moonbase when they arrived, pale and shaken. But they'd come. And they'd endured the lunar flight to get *here*, where they'd all gathered in the well, and toasted the Schramm, and the future.

The elevator stopped. "Penthouse," said Ward, opening up.

They walked out into the cage. It was a relatively narrow space about the length of an ordinary living room. Mesh panels rose not quite shoulder high on both sides. At the rear end, a ladder descended to ground level.

Amy gravitated immediately toward the eyepiece. Its housing was mounted on a universal joint, and projected down from the ceiling. A padded chair had been installed for the observer. "Did they actually come up here?" she asked. "They could see the same image on the monitors downstairs, right?"

He smiled. "They loved it up here. They claimed the image was clearer, that it got distorted by electronic transmission."

Their eyes met and they laughed.

She looked at the chair, and at him. "May I?"

"You're in charge."

"Yes." She sat down, and adjusted the viewing tube. "Hard to believe."

It was covered with dust.

"I won't be able to see anything, will I?" She put her eye to the lens.

"I don't think so," he said. "Depends on the status of the amplifier."

She looked, and shook her head. "Dark. How long will it take? After we put it in?"

"Depends how good an image you want." The unit would collect photo-

tons and provide a picture. The picture would be far sharper than anything one could see through a conventional telescope. "I'd say we should have something in forty minutes."

"I'd like to wait that long then, if you don't mind."

"It's the same picture you'll see at Moonbase."

"Don't care. I'd like to see it *here*."

Ward decided he liked her. He nodded, gave her a thumbs up. "We'll do it."

The cage was equipped with a series of work lamps. He turned them on. In order to get at the amplifier, he would have to remove a secondary mirror. It would be awkward, but he could handle it.

"We have coffee," said Amy, surprised. "Would you like some?"

Ward had forgotten. They'd always kept a coffee maker and an ample supply up here. There was even a Styrofoam cup dispenser and a small basin with running water which, fortunately, they had not shut off. "Yes," he said. "If you don't mind."

She ladled some out of a small green tin into the coffee maker. It smelled good. One of the lamps flashed against the bottom of the container.

"It'll be a few minutes."

"OK."

Ward produced a screwdriver.

The mirror assembly was protected by a glass frame. He began removing screws. When he'd finished, Amy handed him his coffee. "No cream or sugar," she said. "Sorry."

They pulled the frame loose and

set it aside. The mirror was fitted into a set of flanges.

He rotated it and lifted it out. Amy removed the spare amplifier from the canvas bag, and spread the bag out on the floor of the cage. He understood and laid the mirror cautiously on the canvas to protect it from scratches.

The amplifier was a tapered black box with lenses at both ends. He could not see any damage, but then he had not expected to. He released two springs, turned it counter-clockwise, and pulled it free.

"Lovely," said Amy.

"We're in good shape." He inserted the replacement unit, fitted the flanges into the collar, and rotated it. The springs clicked. Perfect.

He handed her a remote. "Would you like to activate it?"

"Sure," she said. "My first official act." She aimed it and squeezed. A red lamp blinked on, and the internal computer hummed.

"We're becoming irrelevant," he said.

"That seems a little strong." Her voice might have echoed through the dome. "They need us to come over and make repairs."

Ward was seated on the floor of the cage. It wasn't comfortable. "There might be another phase coming for us. Maybe when—if—we go to the stars. But meantime you and I will just sit around the pool."

Her eyes fastened on him. "Not even then, Edgar. If there was ever a mission made for robots, it's starflight."

Ward was thinking that she was

correct, and that the probability was that no one would ever *really* go anywhere. And the final quake hit. It rocked the cage, and pitched Amy off the arm of the chair on which she'd been balanced. For a terrifying instant, he thought the cage would break loose. He splashed coffee down his shirt front and leg. Below, a klaxon erupted. The lights flickered, and died.

"Edgar? Are you OK?" Her voice was whispery. Frightened. The shocks were still coming.

Aside from the red lamp on the amplifier, they were in total darkness. "Yes." The klaxon continued to wail.

She moved close to him. "This is going to be a trip to remember." She had stiffened.

"I'm sorry," he said. "It was never like this under the previous management."

They sat in the dark and waited.

"We'll be fine," Ward said. "After we're sure things have settled down, we'll clear out."

"Is the elevator working? Can you tell?"

"No. The lights are out."

"How do you get down?" She almost concealed the quiver in her voice.

"There's a ladder. We'll be OK."

Conversation in the dark, whatever the specific circumstances, tends to become intimate, takes on a dimension of truth that lamplight dissipates.

"So," said Ward, feeling her proximity more intently than he had at any other time, "How do you like the Moon so far?"

"It's a little scary," she admitted.

"But, if I had to go through a quake, I'm glad you were along."

"Thanks," he said. He used his remote to silence the klaxon.

"I wanted to come to the Moon," she told him, "because this is where you get your ticket punched. You run the Schramm, you get to meet everybody. They *all* have to deal with NASA/Smithsonian's director. They will want to keep me happy. I expect to put in my two years, and go back to a choice assignment." He could sense that she was smiling. "Like you."

"What makes you think it works like that?"

"Hard to see why it wouldn't."

"You're going to find that people are more apt to remember the things you've denied them. I wouldn't want to discourage you, but I fully expect to spend the rest of my career staying ahead of the lynch party."

The jolts lessened and became infrequent. And stopped.

The darkness was not quite stygian; he could see his hand in the glow of the status lamp.

"Edgar," she said, "do we have a flashlight?"

"No," he said. "Not up here. We have a few in the annex."

She laughed.

"What?" he said.

"I think we've had a demonstration of why we shouldn't be out here."

Maybe this is why we should be out here.

He heard her moving around. "I think the coffee maker's still working. And the telescope. We've got the important stuff."

"Good." It was a poor way to end

his long association with the observatory. He sighed. "No point putting it off," he said. "Let's start down."

"Wait a minute, Edgar. I haven't seen the quasar yet."

"You *still* want to bother with *that*?"

"After all this? Of course I do."

When the red lamp went green, Amy was already in the observer's chair. Ward heard the clean metallic sound of the eyepiece moving, and then the sharp intake of breath. "It's *beautiful*."

When she had finished, he took his turn.

The quasars, seen through the Schramm, were always spectacular. On this night, as Ward finished up what he considered the meaningful portion of his career, none had ever been more so.

4C-1651 was a brilliant blood-red star.

More than a star: a fire in the night. A blaze. A conflagration, frozen in time and space. A dazzling beacon on the far edge of creation, removed from him by unthinkable immensities. The photons entering the telescope's system of lenses and mirrors had begun their journey billions of years before the sun was born. Before the lights in the Milky Way had come on.

He felt a hand on his shoulder. "You're right," said Amy. "This is the place to see the show."

The descent was not difficult. Half-way down, Amy called his attention to a cool breeze. "This place is *drafty*," she said. Ward had never

used the ladder before, and he ascribed it to their exposed position. But when they got down, he detected no change.

They started through the dark, across the floor, toward the passageway.

"Edgar, you don't think we've sprung a leak, do you?"

"No." *Punch a hole in the air seal, and you got a catastrophic event. Right?*

Ward remembered the area as being generally open, but they encountered consoles and shelf units and work tables everywhere. After he got poked in the eye by something that fell over on top of him, he walked with a hand extended in front of his face.

They found a wall, and a few minutes later they arrived at the airlock. He located the control and tried the GO button. "Power's off here, too," he said. "We'll have to crank it."

Her voice came out of the dark. "Can I help?"

"Just stand clear." The emergency panel provided access to a wheel. He turned it and counterweights moved in the walls. He heard the metal door lift.

Amy moved past him to check progress. "Keep going," she said. "The passageway's dark, too."

Starlight spilled through. When the door was about halfway up, they slipped underneath.

"Everything except the telescope and the coffee maker," said Amy. "How do you figure it?"

"Damned if I know. That's the kind of stuff I leave to the technicians."

"I'm anxious to be out of here," she said.

"I think maybe we are losing air. If so, the dome's going to get cold. And that means the equipment will take a beating." He stared out across the lunar terrain. "Damn. First thing we do when we get to the flyer is let Moonbase know." He held up his hands, trying to gauge which way the air was moving.

Back the way they'd come.

It was probably being drawn into the dome. There were ducts on both sides of the lock. He pulled over a chair and stood on it to reach one. "It's going in *here*."

"Maybe it's just circulating."

"I don't think so."

"Then what?"

He tried the other one. And shook his head. "Same here. Maybe there's a hairline break somewhere in the system. We've got a couple dozen of these things scattered around. I hope they're not all sucking air."

They walked quickly through the passageway, grateful that they were able to see again. At the annex lock, Ward pressed the control not really expecting it to work. It didn't.

Amy already had the emergency panel open. She pulled on the wheel, but it wouldn't budge.

"Let me," he said. He twisted it. Put his weight to it.

Ward shifted his position. It was made of rippled plastic with hand-grips. But he strained without result. "Uh-uh," he said, at last.

She looked at the closed door. Looked at him. Fear dawned in her eyes. "Edgar—"

He tried again. And gave up.

"There might be a vacuum behind it," she said.

Panic hovered out on the edge of awareness.

They could see the flyer, resplendent in starlight, on the plain.

"How about the commlink?" she said. "Maybe we can get help."

"Everything's dead."

"We know the coffee maker's getting power. Maybe we could tie into *that*."

"I'm not a technician, Amy. Would you know how to do it?"

She shook her head. "What else do we have?"

He tried the wheel again, shouted at it, gave a final fruitless yank.

"Edgar, is there another way out?"

"There's an airlock in the rear of the dome. But we don't have suits."

"There are no suits in the *dome*?"

Her amazement at the stupidity of the arrangement was apparent.

"We've never had a reason to keep any out here." Ward tried to think. "We need to get a commlink working. Which means we'll have to string cable down from the cage."

"That sounds like a *lot* of cable. Where do you keep it?"

His heart sank. "In the annex."

"Behind the door."

"I'm afraid so." My God.

"This place is certainly well laid out for an emergency." Her voice was getting an edge. "Look," she said. "Moonbase monitors seismic events, right? They must know we've had a quake."

"I hope so. They might suspect we're in trouble. If they do, they're

trying to raise us right now. When we don't respond, they'll come looking."

"But—?"

"It's late at Moonbase. Almost two in the morning. I doubt anyone will even notice there's activity until they come in tomorrow and read the printouts."

"Wonderful."

"I *am* sorry. I guess we've become complacent."

"I guess so." Overhead, a comsat was moving. *Twinkle, twinkle.*

"Maybe they'll get worried," he said, "when the Schramm doesn't come back up on the circuit."

"They might. But that won't be until tomorrow morning either. Remember we told them we could be down for a few hours."

Ward's stomach felt cold.

"Maybe we could disconnect one of the commlinks and take it to the cage?"

He saw no other choice. But he didn't know a thing about them. And they'd be working in the dark.

She looked at him, and anger flashed. "Come up with something, Edgar."

He looked away from her. Toward the floor. Up at the comsat.

Her eyes followed his. "If we had even a flashlight," she said, "we could sit here and bounce an S.O.S. off the thing."

The search for the flashlight was desperate, swift, and futile. They moved through the dark dome, yanking open drawers, feeling tabletops, struggling with cabinets. Ward's frustration raged. How could they have

been so negligent? What was the point of compartmenting if you *had* to be in the annex to survive?

How could he have been so dumb?

They groped through doors and across desks. He checked the washroom. She examined the operations office.

Almost two hours had passed since the quake. And the air was beginning to feel a trifle stuffy.

The telescope towered overhead. "You know," she said, "we've got a *quasar* inside that thing. And we can't produce a goddam *flashlight*."

He sat down on a desktop. "Not a very auspicious start for you," he said.

She banged a door shut. "Nothing," she said. "I can't believe there isn't one here somewhere."

Quasar. She was right: their quasar was brighter than a thousand galaxies. Why did they need a flashlight? With an index finger he couldn't see, he drew an imaginary line out of the eyepiece toward the side of the cage. Then down onto the floor of the dome. Toward and through the slightly less black patch of darkness at the airlock into the passageway. And *up* into the sky. Four lines. Three changes of direction. "Amy," he said, "there's a mirror in the washroom."

She did not answer.

He was redrawing his lines. No reason why it should not work. "My watch case is reflective. That makes two."

"Edgar, what are we talking about?"

"You're right," he said. "We've got light. All we have to do is get it to the comsat."

She touched his wrist. "*It might* be

possible.” Back out in the passageway, where they could see, she produced a pocket computer and released the cover. Stars glittered in the polished metal. Not perfect, but close enough.

Three.

The washroom mirror was metallic. It was framed over the basin, about the size and dimensions of a medicine cabinet. Pieces of the wall came out with it.

They selected a location on the floor that combined lines of sight with the cage and the passageway. When they were satisfied, they set a chair in place and put the washroom mirror on it. “Once we’ve got the angle, we’ll tie the mirror down to keep it steady.”

It would be simple. And elegant.

Ward was pleased with himself.

Now he returned to the ladder. *Once more into the dome.* He climbed quickly in the light gravity. Despite the fear, he was actually beginning to enjoy the experience. If he could make this work, it would make a rousing finish to his tour at World’s End. Hell, this was the stuff of legends.

Within a few minutes he was back in the observer’s cage.

The quasar was still there.

He estimated where he would mount Amy’s computer cover, a little above belt high on the wall to his left. Then he removed two mesh panels, to provide an unimpeded angle to Amy’s position on the floor. He stacked them well out of his way, reminding himself that he now had no

protection on the open side of the cage against a seven-story fall. With the same thought, he felt around until he found and stowed the canvas bag in which he’d carried the amplifier.

Next he turned to the eyepiece assembly. It was held in place by four screws. He removed these, pulled the assembly clear, and set it on the floor. A smear of light now touched the mesh wall about a foot above the table. He opened Amy’s computer, and reluctantly broke off the cover.

He moved the coffee tin and put the cover on top of it, in the light. Now he adjusted the focus. The light beam from the telescope brightened, and a patch of wall on the far side of the dome lit up. “OK,” he called. “We’re in business.”

Amy cheered him on. He angled the beam down the wall. *But the floor of the cage cut it off.* He adjusted the eyepiece housing and moved the mirror higher. Moved it as high as possible. The circle of light drifted down, but still did not reach ground level. “This might not work after all,” he called.

“Why not?”

“Angle’s not so good.” The light beam drifted out into the dome. He felt very high, and very exposed. “I don’t see how we can do it without another mirror.”

She was slow to respond. When she did, her voice sounded tired and far away. “Is there another washroom?”

“In the annex.”

“How about the telescope? Maybe there’s a spare mirror in the telescope?”

“No—”

"A redundant mirror, maybe? Reflective metal? Do we have reflective metal anywhere?"

"I wish," he said, "we had some lights in here. There might be something, but I'm damned if I can think what it might be."

He heard a crash, and knew she had tossed something. Bostonian good manners giving way to frustration.

Maybe the bureaucrats were right. Maybe this is no place for people.

He sank down, between the observer's chair and the table. The computer cover was rectangular, about the size and general dimensions of his hand. The mirror itself was dark, though he could see the red reflection of the quasar at the far end of the cage.

Amy's voice floated up from the well. "Coffee," it said.

Ward was weary, and in no mood for jokes.

"Coffee," she repeated. "*Use the coffee tin.*"

The light beam struck the computer cover, which was tied to the mesh wall with strips from Ward's sleeves and angled by packing the canvas bag behind it; traveled on a moderate downward trajectory until, at the far end of the cage, it glanced off the bottom of the coffee tin, which was tied to a table leg by shoe laces and the rest of Ward's shirt. It fell seven stories to the bathroom mirror, to whose stability Amy had contrib-

uted her blouse; passed through the air lock, and was deflected by Ward's watch case back into the sky. Toward the approaching comsat.

Three shorts. Three longs. Three shorts.

S.O.S.

"We were lucky," she said, spearing a piece of cheese.

Ward sipped his drink and smiled. "Lucky, hell. We were *good*. We saved ourselves. And we saved NASA a lot of money."

"We were *lucky*. Where would we have been if you hadn't had a shiny watch case? Of if I hadn't been carrying my computer?"

"We'd have come up with something else."

"You say. Listen, this experience underscores the philosophy that deep space should be left to robots and automated systems." She dipped her cheese into the mustard, and gracefully swallowed it. "Things go wrong too often. When they do, people die."

"When they do, people make it work anyhow." He smiled at her. At that moment, he was aglow with self-satisfaction. "They can't send us home. Somebody has to be available to pick up the pieces. We'll be going back to World's End, Amy. And beyond."

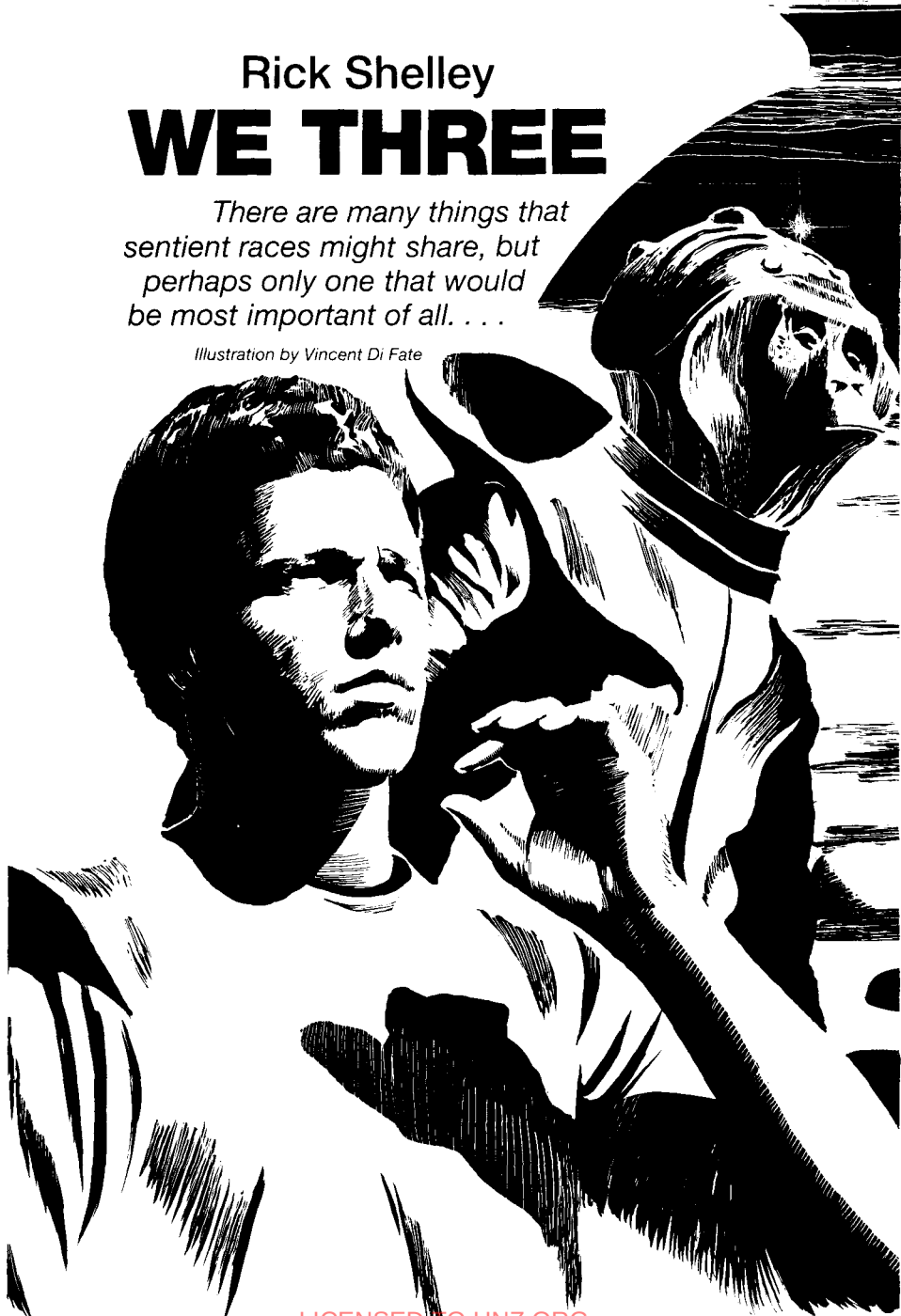
"Ward's Corollary to Murphy's Law."

"Yeah. You could say that." He finished off his drink. ■

Rick Shelley
WE THREE

*There are many things that
sentient races might share, but
perhaps only one that would
be most important of all. . . .*

Illustration by Vincent Di Fate





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4
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Here

Picture our Galaxy in your mind. Look at it from above, so that the disk and the arms of the spiral are visible. Superimpose a pair of radii marking a 90-degree wedge of the Galaxy. Place Earth fairly close to one of those radii, a little more than halfway out from the center. We are talking about billions and billions of stars, and billions and billions of planets, and distances so vast as to be meaningless in any emotional way.

In all of that vast expanse—from the core out to where the stars are so far apart that even through hyperspace it takes years to get from one to the next—there are only three sentient races. . . .

"Hold on! Just a minute!" I straightened up in my chair and held up a hand. The audio track stopped. The image on the television froze. The room lights came up, just a notch.

"Yes, Dr. Gerkel. Is there a problem?"

"Why are you showing me this grammar school explanation? One of my assistants scripted it to my outline."

The lights came up the rest of the way. There were five of us in a conference room that could have held thirty without crowding. The others were all looking at me after my outburst. I'd like to think that the frown I could feel on my face was not typical, but I'm sure I could get an argument. *I've done it again*, I thought.

"Sorry, Doctor," Lynn Grosskreutz said. Although she too holds a doctorate, she hates being addressed as "Doctor." Since she became senior

science advisor to the President, that hasn't been easy. "My instructions, from both the President and the Secretary-General, are to make this final briefing as comprehensive as possible."

I held up my hand again to stop the explanation. Then I took a deep breath and let it out. This wasn't the time to throw a snit. I could feel the frown melting from my face. Calm down, Ben, I told myself. Nice and cool.

"I'm sorry, I didn't mean to snap," I said, pleased that my voice sounded sociable. I had already had separate meetings with the President and the Secretary-General. "It's just that . . . well, I'm feeling a lot of time pressure, you understand?" Lynn Grosskreutz nodded, rather tentatively. "To the best of my knowledge, everything we've managed to learn about the elviri and the camsofetu has been routed through my office, and I have diligently studied every word and picture of that flow."

"Yes, Doctor," Lynn said when I left a pause for her.

"I know you have your instructions, and I guarantee that I know how important all of this is, but why don't we start from here? Is there anything that hasn't come through my office on the aliens?"

Lynn looked down at the table. "Nothing in this presentation, I'm sure." She met my gaze and gave me a nervous smile. We knew each other mostly by reputation, and she appeared to be more than a little intimidated by mine. My outburst hadn't helped. "I'm certain that we got all of

our information from your office.”

I chuckled and shook my head. I don't think it sounded too phony. Dr. Grosskreutz and the others all seemed to relax a little. “If you don't mind, I'll take the presentation to look through on the ship. That will give me plenty of time, just in case there's anything I've forgotten, or a new slant I haven't considered.”

“Of course,” Lynn said quickly.

“It's just that. . . .” I shook my head again, still trying to change the tone of this meeting. I don't *like* to appear confrontational all the time. “I guess I'm more nervous about this than I've let myself accept.”

“I can understand that,” Lynn said.

“*Guinness* has already announced that they're going to create several new categories for all of the firsts and records I'm about to make.” I know I flushed at that statement. “First human to ride on an alien spacecraft. First human to travel out of our Solar System. First to experience hyperspace. First ambassador to an alien race. All that nonsense.” I stopped and looked around. I wasn't acting at all now. I was acutely embarrassed by all that I had said. I had been trying to explain why I was so edgy, and I'm afraid that it simply sounded as if I were bragging.

“I'm going to be away from *all* contact with humans, for at least a year, possibly two or three. I have only the vaguest idea what I'm going to experience. I'm going to be in the fishbowl with the only two other sentient species we know of, forming much of their impression of us from what I do and say.” At least the aliens wouldn't

have my reputation to color their opinions. Still, I was going to have to be damned careful about what I said and did.

“There was a remarkable consensus that you are the right person to be in that position,” Lynn Grosskreutz said.

I knew what she meant. Everybody figured that I was the only person with both the talents needed to have a chance to succeed and the ego not to be daunted by the prospects. A reputation can be helpful at times, but it can also drop you hip-deep in the you-know-what. It wasn't just that I was being put on display for two alien races. I was also supposed to observe and ask intelligent questions, learn everything I could about the aliens and their technology in whatever time I had. See if they were keeping any secrets.

One helluva lot of expectations to live up to. My ego does not preclude self-doubt. It just keeps me from showing it.

Two years had passed since the elvirti first came to Earth. They had been polite visitors, and as helpful as possible. There had been no threats or demonstrations of force, no demands or orders. The elvirti even managed to avoid giving the impression that they were superior beings come to guide poor benighted Earthlings into the light. Still, few people on Earth had escaped the feeling that the human race was being judged. The elvirti proposal that a single delegate from Earth make the trip with them to the home world of the camsofetu had revived the earliest mis-

givings.

"The camsofetu are much wiser than we are," the elvirti assured us. "They will know what we three should do now that we have found each other."

Or what elvirti and camsofetu should do about humans.

From Here to There

The elvirti starship didn't look all that impressive during my shuttle ride up to it, until I thought about the dimensions. The ship looked like a series of boxes connected by scrap rods and beams. But that collection was 673 meters long, and as much as 87 meters in diameter. As the shuttle made its final approach to dock with the alien craft, the ship seemed to swell out on either side of us until the ship was all we could see.

"Welcome aboard, Mister Ambassador," Captain Taemon Oelievay said as I emerged from the airlock in the ship's command module. "I hope you will enjoy your passage with us."

The elvirti can be called humanoid only by stretching the definition to transparency. They are bipedal, bilaterally symmetrical, and so forth, but the Earth creature they most resemble is an orangutan wearing an armadillo's hide. Their arms are longer than their legs, by as much as a third. Hands and feet have four digits tipped with claws that appear designed for digging—rather like a mole's. What most people notice first about them, though, is the eyes. The irises are invariably a bright cerulean blue, surrounded by a ring of either bright scarlet or a reddish purple.

"I thank you for permitting me to travel with you, Captain," I replied. The elvirti spoke in English. My reply was in Dassau, the elvirti language. I had rehearsed my opening statement. My command of Dassau was minimal. I understood it better than I spoke it, and I had made almost no progress learning to read and write the language.

"I will show you to your quarters myself," Captain Taemon said. The captain was of fairly typical size for an elvirti, 150 centimeters in height and slightly over 120 kilograms in mass.

"You honor me." After that, I lapsed into English, from sheer necessity. It didn't matter. Captain Taemon was fluent in English. The elvirti all seemed to have developed fluency in several languages.

"I've never been in space before, not even this near to Earth," I said. What I meant was that I was not at all comfortable with near-zero gravity.

"It is only this initial period that gives unease to first-time travelers," the captain replied. He obviously sensed what I was hinting at. "Once we are outbound and make the shift into hyperspace, there will once again be a proper gravity under our feet."

I nodded twice. The nod was a gesture shared by the two races. The difference was that elvirti always nodded twice.

"I hope you will not be too uncomfortable during our journey," Captain Taemon said when we reached the cabin that would be mine during the next five months—and, most likely,

for another five months during the return voyage. "Our far-doubles are not designed for creature comforts." Not for human concepts of creature comforts, in any case. The elvirti lived aboard their ships for years, even decades at a time. The accommodations suited them.

The baring of pointed teeth was an elvirti smile, not a threatening gesture. Still, I had to consciously steel myself not to flinch.

"I'm sure there will be no problem," I replied. I would make do.

"We will have a sufficiency of opportunities to talk during the voyage," Captain Taemon promised. "But for the time, I must take my leave. My duties call. We will be underway within"—he paused for a moment to translate elvirti time units—"fifteen minutes."

"I would like to watch our departure, if that is possible," I said.

"I will send someone for you."

The elvirti are a young and adventurous species. Their written history goes back only 3,500 years. At the time they "learned" to write, humans had already been writing for 1,500 years. The greatest ages of pharaonic Egypt had come and gone. Empires had risen and fallen. One of the mental games I used to occupy my time during the voyage out from Earth was to compare the time-lines of elvirti and humans. From the emergence of a written language, it had taken humans 4,900 years to fly their first airplanes. It had taken elvirti slightly less than 2,000. Earth's civilizations had been little different 2,000 years after

the appearance of writing than they had been at the beginning. There were still pharaohs in Egypt. Technology was still in the Bronze Age. Even the great Greek philosophers were centuries in the future. The elvirti needed another 300 years to reach space above their home world. In that, at least, humans had been faster—roughly a half century from the Wright Brothers to the X-15. But within a hundred years of making their first tentative flights above the atmosphere, the elvirti were traveling among the stars. Until the coming of the elvirti though, humans had no idea that hyperspace travel was possible. The mathematics of it are still being unraveled. There are several stages between the limit of our scientific knowledge and that needed to achieve hyperspace technology. Even with the full assistance of the elvirti, it looks as if human-built starships are still decades in the future.

On the other hand, television (as an entertainment and news medium) was a new concept to the elvirti when they came to Earth. Most elvirti manufacturing is little advanced beyond the master and apprentice stage. Mass production and assembly lines are only beginning to make their appearance.

But in the last 1,200 years, Elvirti starships, their "far-doubles," have ranged through an entire quadrant of the galaxy. They have visited more than twelve billion star systems, surveyed or landed on half that number of terrestrial planets, and found ... only two sentient species besides themselves, and the artifacts of ex-

tinct civilizations on four other worlds.

"Why?" is a popular question.

I had the run of the ship during the trip to Bekkai, the sole world of the camsofetu. The interior of the elvirti ship was a maze. While the operating sections were easily accessible and efficiently laid out, other areas, living and storage areas for example, could be quite difficult to get to, or out of, until the trip had been made several times.

My major regret was that there were few locations from which I could see out of the ship. There were viewpoints in the command centers, but no provision had been made to permit passengers to sit and look out at the stars.

Even in hyperspace, there are stars to watch. The view is unbelievable. I had never guessed at the complexity that stars might show in other dimensions—and hyperspace is rooted in dimensions other than those in which humans, or elvirti or camsofetu, routinely live. Describe it? I might be able to do it mathematically, with a lot of help, but I despair of finding a way to describe it in words. At times, it was almost like being inside the stars, looking out in every direction at once, seeing every possible color, churning in fractual patterns of incredible complexity. And beauty.

Nearly all of the crew, and many of their dependents, spoke English. There was always someone to answer my questions and I asked, literally, thousands of them during the voyage. I carefully logged each question, and

the answers, in my portable computer.

It's a good thing I brought my own computer. The elvirti computers work only with their own language, and in five months I barely made a start at learning to read that. While it's not so complicated as some Asian languages, it is much more intricate than English, German, or Spanish, the three languages I'm fluent in. The elvirti alphabet has thirty-seven characters, but each can be written in two different orientations, right-side-up or upside-down. Stress and pronunciation are indicated by the relative size of letters within a word. Verb forms are invariant. Tense, person, voice, and number are indicated by the declaration of nouns, pronouns, and adjectives.

Elvirti space travelers take their families along. The far-doubles are sometimes gone for decades at a time, exploring or making routine runs between elvirti outposts. They have planted colonies on thousands of worlds and in hundreds of long-term spacehabitats.

"It would be impossible for us to complete a census of our kind," Captain Taemon told me at dinner one "evening." "By the time we could get the numbers collated, they would be too hopelessly inaccurate for us to be able to do anything except file them as historical data."

Calling the meal dinner was simply my way to keep some sense of diurnal rhythm to life aboard ship. The elvirti didn't bother. They apparently evolved to be independent of the cycles of dark and light. The day on

their native world was thirty-two hours long but they had adapted to different days on so many worlds. They tend to sleep about two hours out of twenty, but can do without for much longer, without losing any mental acuity. I learned early in the voyage that I had to be careful about my rhythms. It was far too easy to forget, to extend my waking hours beyond all reason, until my mind was scarcely functioning. Giving each meal a name helped.

"Historical data isn't enough of a reason?" I asked.

Captain Taemon bared his teeth. By this time I no longer flinched even inwardly at the gesture. "Why spend time on yesterday?" he asked.

That is perhaps the hardest thing for humans to get used to in dealing with the elvirti. They rarely refer directly to money. They do have money, and all that goes with it, accounting, taxes, and thieves, but they don't mention money as money. Their unit of exchange is a unit of time. Even their coins and notes are named for units of time. And it is the time that elvirti talk about. They appear to be even more obsessed with time than humans. I knew we have clichés such as "Time is money," and we talk about "spending time," but there is a much more literal sense to the elvirti usage.

"We've found that knowing as much as possible about yesterday makes it easier to plan for tomorrow," I suggested. And I thought, *Government certainly couldn't exist without the tons of statistics we generate.*

"Tomorrow is not yesterday," Tae-

mon Oelievay said. "Knowing how we functioned before we found your people does not even begin to hint at how we must function now that we have."

That gave me too much to think about for me to continue the conversation.

I knew starting out that I faced at least ten months away from all contact with other humans, perhaps considerably more. The elvirti invitation was only for one. They said they didn't have room to care for more than one human. It was time they could not afford to spend. One human only, man or woman, old or young. They offered no advice or preferences. They simply told us that they would take one human to meet the camsofetu.

I had thought that I was proof against homesickness or lack of contact with other humans. The elvirti are sentient, even rather personable. They made no demands, and they were, in almost everything, as helpful as grad students trying to stay on the good side of their dissertation director. "I don't like people all that much," I told the President when he called me to Washington to ask me to undertake the mission. I was only half joking. I'm not certain which half the President saw, the joke or the seriousness. I've always been more inner-directed, uncomfortable around crowds. I live inside my head. I'd rather spend twelve hours interfacing with a computer than twelve minutes talking with most people I've met. I'm more at home with the computer. I

know what to expect. I know what I have to give.

I won't say that I got *lonely*, but the trip did change me.

The home world of the elvirti is 3,000 light-years from Earth. The world of the camsofetu is 12,000 light-years from Earth, and 14,000 from Elvirti (the planet). Still, the elvirti found the camsofetu long before they found us. The elvirti had concentrated their searches farther in toward the center of the Galaxy. "We expected that we were more likely to find others there," Captain Taemon explained. "We would spend less time if we found others who might already have found still others. We pressed outward only after our inward search proved to be so futile."

"Have you expanded your search to either side of this quadrant?" I asked.

"I assume that the search area has widened," Taemon Oelievay conceded. "I do not know this for fact. It is for others to spend that time."

"What can you tell me about the camsofetu?" I had asked that before without learning much. Captain Taemon, all of the elvirti, seemed reluctant to speak about the camsofetu—or any of the worlds where they had found evidence of extinct peoples. They never *refused* to answer, but their replies seldom helped much. It was the one subject on which they were reticent.

"The camsofetu are much wiser than us," Oelievay said. That was usually the extent of his answer. I was ready to ask something else when he

spoke again.

"The camsofetu are much older than we are. They have unbroken written annals going back," there was a pause while he calculated the conversion, "more than seven million of your years."

"Yet you found them. They didn't find you?"

"How could they?" Oelievay asked, his eyes going wide, showing a clear circle of white around the red and blue. "They never leave their home world."

"They never discovered how to use hyperspace?" I asked.

"They had the theory, with remarkably few errors. They never applied it. They had never even lifted themselves above their atmosphere."

"Never?"

"They chose not to spend that time."

The camsofetu, as a civilization, had a *written memory* seven million years old. I spent many hours in my bunk, staring at the overhead, trying to comprehend a people who had a written history that went back so far. "How did they survive?" "How did they avoid poisoning their world or killing themselves off some other way for all those eons?" With all the difficulty we've had simply dealing with our wastes this last few decades, I was stunned at the thought that another race had managed to last so much longer.

They never left their home world. They flew airplanes, or something analogous, but had never ventured into space, according to Captain

Taemon.

"Don't they have any curiosity at all?" How could they *not* use their knowledge to explore farther off than the top of their atmosphere?

A few moments later, I had the counterpoint to that question. "Could a curious civilization have survived that long?"

The camsofetu are much wiser than us. The elvirti used that line quite frequently. The camsofetu were wiser, and older. They had advanced science and mathematics on a theoretical basis, going so far as to uncover the intricate foundations of hyperspace technology, without ever bothering to build a ship to test their theories.

Right, I had images of ancient Greek philosophers too, a milieu spread not just over a few decades or centuries, but over millennia and eons. *Wise Old Camsofetu* sat around working out the secrets of the universe in their heads, disdaining experimentation as something beneath their dignity. I even pictured them holding secrets, *Facts and Technologies* far beyond hyperspace. I could even hear the response: "You didn't ask," in my head.

The elvirti considered the camsofetu to be far more advanced than they were, despite the fact that it was elvirti who had gone into space and explored a full quarter of our Galaxy.

I wasn't ready to grant the camsofetu that much, not without a lot of convincing. I wasn't even ready to concede that they were more advanced than us, even if they had been

keeping records for seven million years. The mental picture I built up of the camsofetu was much too convenient. And . . . less than accurate.

There

White and green and blue, Bekkai lay below our ship. There were six other elvirti ships in orbit when we arrived, and another came in-system as we were settling into our parking orbit. I didn't need Captain Taemon's explanation that a lot of elvirti made the journey to Bekkai—he didn't call it a pilgrimage, though I referred to it that way in my notes—to learn what they could from the camsofetu.

"Your people spend a lot of time at this," I observed.

"Yes." For a moment, I thought that that was going to be the extent of the captain's answer, but he nodded twice, then continued.

"Until we happened upon your world, there were only the camsofetu and us, and they are much wiser than us. Long had we feared that we were alone in the Galaxy. Once we discovered that we were not, how could we *not* spend whatever time we could with them? We learn what we may from them. We tell them of the places we have voyaged. Now, we have humans to visit as well. We will learn from you, and we will teach you."

"Do you teach the camsofetu as well as learn from them?" I asked.

He hesitated, then said, "I believe we do not completely steal their time. We study what they have done in thought. We tell them what we have done in fact. It may help them refine the products of their minds.

We learn new things. We tell them of the worlds we see, and the stars, and everything we discover about our Galaxy. I believe that time is in balance between us."

"Would you break your ties to the camsofetu if you thought they had nothing left to offer you?" I asked next.

I was surprised that he didn't hesitate at all this time. "No, we would not, though our contacts might become less frequent."

"Why not?" I thought that might be the most important question I could ask. It might bear directly on *our* future contacts with the elvirti and, through them, with the camsofetu.

"The twin gifts of sentience and survival are much too rare," Captain Taemon said. "Consider. We have explored one-fourth of this Galaxy. We have looked for life, for sentience, in billions of star systems. In all of that space, only elvirti, camsofetu, and humans have sentience and survive. If we project that figure, there may be no more than twelve sentient species that survive in all the Galaxy, on all of the worlds that orbit more than one hundred billion stars. We are too few to wall ourselves off from each other."

That was a comforting thought, but it also implied one whopper of a burden. I thought about people, human people, and I wondered if we were up to the challenge.

Truth to tell, I wasn't very optimistic. I thought about those four anonymous races who hadn't survived.

"Is there anything I need to know

before I meet the camsofetu?" I asked Captain Taemon as we prepared to take the shuttle down to the surface of Bekkai. "Protocol or anything like that?"

I had broached the subject before, but the elvirti had been short on details. At that point, I didn't even know what the camsofetu *looked* like. The elvirti had never offered pictures or descriptions.

"They impose no rigid standards of behavior," Captain Taemon assured me. "The camsofetu are much wiser than us. They accept that which is."

He still wasn't being very helpful.

"Are there any taboos I should be aware of? I don't want to say something I shouldn't, or do something gauche."

Taemon Oelievay simply bared his teeth in a long smile. When he relaxed the gesture, he said, "Do not worry."

That was one bit of advice I couldn't help but ignore.

Bekkai did have cities, but they weren't as large as Earth cities. For a civilization that was seven million years old, the camsofetu appeared to have kept their numbers well in check. My first impression was that the world couldn't possibly have a third the population of Earth. Of course, I was basing that guess on a total lack of real knowledge.

Captain Taemon had no name for the city we were heading toward other than "The city where the camsofetu meet strangers."

"What do the camsofetu call the city?" I asked.

"The city where we meet strangers," he said.

I wondered what they called it before the elvirti came, but I didn't think I would get a useful answer, so I didn't ask.

The elvirti shuttle isn't as limited as ours, by orders of magnitude. The bit of their technology that had impressed me most from the beginning was their lightweight antimatter drive. The smallest of the elvirti matter-antimatter power systems weighs less than 200 kilograms, fully fueled. That's small enough to use even in a subcompact automobile, with enough fuel to carry a 1,500 kilogram auto a couple of 100,000 kilometers. And that might be the first use we put it to.

On the other hand, we appear to be years ahead of the elvirti in computer science. My little portable was the single most powerful and fastest computer aboard the elvirti far-double. The far-double uses a three-tier hierarchical network, with hundreds of systems on the lower level controlling individual modules or ship-systems. The middle layer collects and collates relevant data from those units and reduces it to the forms needed by the top level, the single computer that controls the network. By our standards, the computers in the middle are "minis" and the top unit a mainframe. Their display units are about as primitive as the televisions that were available for the broadcast from the New York's World Fair in the 1930s.

Captain Taemon piloted the shuttle himself. There was only one other

elvirti riding down with us. She stayed in the shuttle after we landed.

When the hatch opened, I saw my first camsofetu.

During the voyage out, my mind had dreamed up a lot of fanciful possibilities. At one point, I assumed that the elvirti reluctance to describe the camsofetu meant that they would appear as hideous as something out of the worst of the mid-20th century paranoia-sci-fi films. Perhaps the least imaginative of my nightmare images had the camsofetu as humanoid but with great bulbous skulls to house a brain two or three times the size of the human brain. I know I got *that* image from one of those old movies.

The reality could hardly help but be more prosaic than my fanciful imaginings. The camsofetu didn't even have tails.

Nuts and bolts: the camsofetu who met the shuttle could have worn my clothes. That isn't to say that he looked human, or like anything on Earth. What I could see of him—head, neck, forearms and hands, and lower legs—was totally hairless. The camsofetu's head was roughly the same size as a human head, but somewhat flattened. The eyes—almost solid black, with only a trace of white around them—were set wide apart, on the "corners" of the head. They protruded, enough to give the camsofetu almost wrap-around vision. My guess is that they have a field of view approaching 270 degrees. The eyes can work together for stereoscopic vision, or separately, one looking off to either side. The nose looked like a calloused elbow. It was set above and

between the eyes, call it in the middle of the forehead. The mouth was directly in what would be the chin of a human, and about fourteen centimeters wide. The upper "lip" was on the face, the lower seemed to mark the top of the neck. The teeth, wide and chisel-like, met at a 120-degree angle. The effect was rather like standing mouth to mouth with a shark. Broad, squared-off shoulders, oriented a bit more to the front than the human equivalent. The wrist structure was ... different from human; the hands were joined to the arms at an angle, and the range of movement was altered by that. Six digits on the hands, with the ones on either end considerably shorter than the rest and attached at almost-opposing angles.

As far as dress, I thought of this camsofetu's clothing as "early Cossack"—loose shirt with baggy sleeves, loose trousers with baggy legs. The sleeves reached almost to the wrists. The trousers stopped fifteen centimeters above the ankles. The camsofetu's foot gear looked vaguely like purple suede boots with pointed toes.

"Welcome," the camsofetu said when Captain Taemon and I stepped out of the shuttle. "My name is Biro-Kiri 1-7-3." One-seven-three is the way he said it.

To avoid awkwardness, I plan to write down the dialogue as if this was the way it went. Actually, Biro-Kiri spoke in his language and I spoke in English. Captain Taemon translated everything in both directions.

"My name is Ben Gerkel," I replied. Captain Taemon's rendering of that

was too long to be simply a translation, so I assume that he introduced himself, and perhaps added a little more about me.

"We have been looking forward to your visit with extreme interest," Biro-Kiri said. He made a clicking sound with his teeth. Captain Taemon explained that the sound was an intensifier (sort of an "and how!" I guess).

The camsofetu couldn't possibly have known that it would be me who would visit, but I knew that the elvirti had dispatched word of their discovery of Earth to the camsofetu, so it was no great surprise that they knew about humans and expected a visit.

The opening pleasantries took another ten minutes. Then Biro-Kiri said, "If you will do me the honor to accompany me?" and he gestured toward the nearest building, which was two hundred meters away.

We walked.

I had no idea if Biro-Kiri was a VIP or a flunky sent to collect me. I had to act as if he were the equivalent of a secretary of state even though he was there alone, without even the pretense of an entourage.

Expectations and imaginings. With all the build-up I had been getting from the elvirti—"They were much wiser than us"—I was starting to feel like a poor relation, and I wondered if this greeting was the equivalent of being let in through the back door.

The building we went into didn't have the appearance of a transportation terminal. It was large, but empty. The ground floor was one large room, without furnishings or interior col-

umns. We cut across a corner of that room and entered what seemed to be an elevator. Biro-Kiri punched a button on a metallic control panel. There was a moment of . . . nothing, not the slightest sensation of movement, no hint of going up or down. Then the door opened again, and we were definitely not in the same place.

I looked at the floor and sides of the doorway when we exited. I saw no hint of "elevator" there. Teleportation? No one had mentioned that. I was certain that the elvirti didn't have that technology aboard their far-double.

One more question—one more series of questions—to ask.

Captain Taemon and I followed Biro-Kiri down a corridor to the right, across an open space that was furnished with several padded benches and a number of flower arrangements, then down another corridor. At the end of that corridor, there was another room, about eight meters square.

"Please sit here," Biro-Kiri said, looking at me and indicating a plush chair. Then he seated Captain Taemon and sat himself. The arrangement was triangular, with a three-sided "coffee" table in the center, and end tables flanking each of the chairs. There were carafes of water on the end tables. A silver tray on the center table held what appeared to be a selection of fruit pieces.

The chair was comfortable, though the seat was somewhat longer than the chairs back home. The edge pressed against the backs of my knees.

"A third sentient species," Biro-Kiri said. He paused to give Captain Taemon time to translate that much before he continued. "We postulated that there had to be at least one more in our quadrant of the Galaxy. Perhaps there will be more, perhaps not."

"Do you feel that the other, ah, quadrants of the Galaxy will hold similar numbers of sentient races?" I asked.

Biro-Kiri tilted his head to the side. He blinked, the eyelids closed from the sides, then said, "That is not the question we expected you to ask first."

He didn't continue, so I had to ask, "What question *did* you expect first?" I had a sinking feeling in my stomach, as if I had just failed some important test.

"Yes, we expect that there will be sentient races in the other quadrants," he said. Blink. "Perhaps an average of two per quadrant."

"There is little chance of contacting more distant races," Captain Taemon said. "The distances are simply too great, even through hyperspace. Elvirti will widen the explored wedge of the Galaxy on one side. It will be up to humans to push to the other side."

"In time," Kiro-Biri said after Captain Taemon explained what he had told me, "perhaps one or the other of you will contact the next sentient species and they will be able to extend the community of sentients."

"Why don't camsofetu travel?" I asked.

Three quick blinks. "That was the

question we anticipated first," Kiro-Biri said. He made that clicking noise again. I felt a little better.

"Humans have long speculated on the possibility of other sentients," I said when it appeared that my question wasn't going to be answered soon. "Some imagined a Galaxy with hundreds, even thousands, of sentient species. Others held, until the arrival of the elvirti, that we were the only one."

"How . . . remarkable," Kiro-Biri said. He looked from me to Captain Taemon, as if seeking confirmation of what I had said. The captain's expression did not change. He didn't answer by word or gesture.

"It is easy to disbelieve in something for which you have no evidence," I said.

"No evidence? You thought your kind was unique in all the Universe?"

"Some people did," I said. "Not a majority, I'm sure. But even of those who did assume that there were other intelligences, many, if not most, doubted that we would ever meet them."

"Please, try some of the fruits. I can assure you that nothing we can eat can be harmful to you." Kiro-Biri gestured to the tray on the center table.

I studied the selection of fruit, trying to decide which looked the least alien. After eating elvirti food for five months, I didn't have any serious misgivings about trying camsofetu food. Our people had studied elvirti food to make sure that it would provide the necessary nutrition and not prove toxic. I certainly didn't think that the camsofetu were going to poison me.

Eventually, I settled on a light green wedge that had the consistency of cantaloupe and took a cautious nibble. It was sweet and juicy, with an almost minty aftertaste, but I couldn't say that it tasted like anything in particular from Earth.

That one bit of fruit kindled my appetite. Since Kiro-Biri appeared ready to watch me eat the entire platter, I did spend a little more time munching, trying each of the varieties of fruit. The only thing that tasted like anything I was familiar with looked like a cherry but tasted like a peach. I had several of those.

"I didn't realize that I was hungry. Thank you," I said when I had finished. I leaned back in my chair and stared at Biro-Kiri, quite prepared to wait as long as I needed to for him to say something more than, "You're welcome."

"We dislike any travel that is too far to walk," he said after perhaps two minutes. "When travel is absolutely necessary, we travel. We have land, sea, and air vehicles. Those have fallen into disuse lately."

"Because you finally developed a workable teleportation system?" I asked, interrupting. It might have been considered rude, but I wanted him to see that I had figured out how we had gotten from where we had been to where we were.

Click, click, click. After that, he was silent again, but not for long.

"You are perceptive. Yes. The system we used was a matter projector. The elvirti provided us with the last clue we needed to perfect our theory."

Well, the benefits go one way at least in this relationship, I told myself. I still didn't see what the elvirti got out of it, not in any material way. Intangibles are fine, but I couldn't see them as being enough to sustain commerce between the two species forever, even if the elvirti had some deep-seated fear of being alone in the Universe.

"Do you plan to extend your teleport system into space?" I asked. I had to amend my preconceptions of the camsofetu. They might be philosophers, but they were willing to do the experimentation and engineering necessary to turn a theory into a practical working system.

I think that what I saw on the camsofetu's face at that suggestion was shock. His eyes opened so far, I thought they must pop out of their sockets. They went from staring at me to staring out to either side. The right eye seemed to flutter. Biro-Kiri closed both eyes—it was more than a blink this time. Then he took a deep breath.

"We would not do so even if it were possible," he said.

"You *know* that it's not possible? You've made experiments to see whether or not you could do it?" I fired those questions out together, quickly, not waiting for Captain Taemon to translate the first before I hit him with the second.

Biro-Kiri did not lose control of his eyes this time.

"There is nothing beyond our world that is so vital that we would leave to seek it. The elvirti bring us empirical knowledge, confirmation of

our theories, news of their long searches. In time, other humans will come to Bekkai. You will tell us of your searches, your knowledge. We will give you what we can in return, the wisdom of our many ages. But the theories that gave rise to the matter projector net would not work at the distances required by even modest space use. In any case, it is necessary for there to be a matter projector at either end of the journey. In space, there would be no point in making the journey by ship just to be able to make the same journey by projection, even if the technology were able to cope with those distances."

"The elvirti could carry the units, position them. There are power sources sufficient to power them over great distances, if that is the limiting factor. If your technology suffices, you could tap the energy of stars."

"Camsofetu belong to Bekkai," Biro-Kiri said. There seemed to be a definite finality to the way he spoke. Captain Taemon put the same sort of inflection to his translation. The subject, it seemed, was closed.

"You upset him!" Captain Taemon said when we were alone, after another jump through the camsofetu teleport system. There was amazement in his voice, as if he hadn't believed it possible to upset a camsofetu.

"I asked questions. I was under the impression that camsofetu rather like being asked tough questions."

"Yes." Captain Taemon went silent then.

"Remember, you didn't give any clues on what I should do or say."

We were in what passed for a hotel in "The city where we meet strangers." Since camsofetu travel only when it is absolutely necessary, large hotels are not a promising business venture on Bekkai. Call it a small inn. I doubt that there were more than a half dozen guest rooms. The establishment was family-run. The impression I got was that it was, somehow, the family's *duty* to offer hospitality on a limited scale. Captain Taemon and I had adjoining rooms. There was a communal dining room that served all of the bedrooms around it. We were the only guests though. The furnishings were spartan in appearance, but comfortable enough.

"Just what kind of job does Biro-Kiri hold?" I asked. "Is he a government minister, or just some low-level bureaucrat?"

"He is Biro-Kiri 1-7-3, that is all."

"That's just his name. What does he do? What is his function?"

"He is the one awarded the honor of speaking with you first. Why he was chosen, I do not know. But do not make the mistake of imposing alien strictures on your picture of camsofetu."

"They *do* have some sort of government, don't they?"

"They manage to govern themselves, but without the sort of formal structures you humans seem to delight in. If a thing needs doing, they choose the proper one of them to do it."

"I forgot, a race of philosophers."

"There may be some justification

for that characterization."

"Did you know about this teleport system?"

"I did not see it the last time I was here. Kiro-Biri 1-7-3 did state that it is new."

"But how could they get a complete system in place since your last visit? It hasn't been all that long, has it?"

"Some dozen of your years."

"I thought you came here after you came to Earth."

"No. We traveled merely to the nearest of our stations, to pass the news. Another far-double world would have carried the information from there."

"So you wouldn't know if they've shared this with your people."

I wasn't consciously trying to sow doubts in Captain Taemon's mind. I was merely trying to resolve my own doubts. He stared at me for a considerable time, even by elvirti standards.

"It is easy to discover. I need only ask some of the others here."

"Can you contact them from here, or do you need to wait until we get back to the shuttle?"

His hand reached for the small radio that hung from his belt. "I can find out from here, if it is truly important to you."

"I think I would sleep better tonight if I knew the answer," I said, and I wasn't quite certain why that was so.

Captain Taemon had to make three calls before he found an elvirti captain who knew about the teleportation system. He was getting ready to carry

the details of it away from Bekkai.

During the next several weeks, Captain Taemon and I followed a regular routine. The primary variation was that some nights we stayed in the hostel on Bekkai, and other nights we spent aboard the ship. Each day we had one or two meetings with camsofetu—one or two of them at a time. They were never the same individuals. *Never.*

"Why?" I asked, before the end of the first week.

"No one wishes to monopolize the opportunity," Tisu-Fira 1-1-6 said. "We recognize that your time with us must be brief. It is our hope that as many of us as possible might have the honor of speaking with you."

"How do you determine who gets to meet me next?" I asked.

Tisu-Fira had difficulty answering that. First off, he opened his mouth as if had a quick reply, but he shut his mouth again instead. He stared at me and blinked. He stared at Taemon Oelievay. And blinked again. Finally he returned both of his eyes to me. There were two more widely spaced blinks before he spoke. "Those who will do the most good by speaking with you suggest the order of meeting."

"And if they disagree?"

"We do not disagree. We know ourselves, and we know those others whose interests and education make them obvious choices. How could there be any difficulty in sequencing?"

I blinked a few times. "Captain, would you explain to our host the

sort of confusion you experienced when you first made contact with us? The people wanting to meet you and your crew."

Then I sat back and watched Tisu-Fira while Taemon Oelievay made his explanation and answered several questions. I still didn't know anything of the camsofetu language, but I was beginning to pick up on their gestures and body language. I saw amazement in Tisu-Fira, perhaps even disbelief.

"That could never happen among us," he said after he had finished quizzing the captain. "I begin to think that you might not have the proper . . . background to understand fully why that is so."

"Then I guess I'll have to take your word for it," I said, perhaps too nonchalantly. The camsofetu had several more questions for Captain Taemon.

"The concept of untruth is not unknown among us," Tisu-Fira said when he turned to me again. "But an untruth tells as much as a truth when the hearer can easily distinguish between the two. They are two sides of the same hand." He extended his hand palm up, then turned it over so the palm was down. Captain Taemon repeated the gesture with his translation.

It didn't matter that I spoke with different camsofetu every time. They obviously shared everything that was said during our meetings. Perhaps those sessions were even broadcast live around Bekkai. I never saw any cameras, but their equipment is considerably more miniaturized than

ours. However it was done, each camsofetu came to his/her meeting fully conversant with all of the previous meetings. The camsofetu memory seemed to be total.

I wish *my* memory was so good. I taped all of the conversations, then used my phonetic recognition program to transcribe them into my computer afterward. I spent increasing amounts of time going back over the transcription, but sometimes I simply couldn't remember every word or nuance, and the camsofetu could, in effect. Bits of prior conversations could crop up in later talks, and it took the camsofetu some time to realize that I couldn't reproduce them all from memory as well.

For several days after my talk with Tisu-Fira 1-1-6, the conversations tended to be markedly shorter than they had been before, and there were always two camsofetu present. Those sessions were intense. I began to feel as if I were up against the entire camsofetu species, as if they were conspiring to wring me out thoroughly.

I really had a feeling that I was being judged... along with the entire human race. I didn't sleep well during that period.

One after another, week after week. The sessions became more relaxed in time. I talked, and I listened. My notes expanded to dozens of megabytes.

Rava-Tonnni 2-4-1 wanted to know about travel and transportation on Earth, local and long distance travel, how much freight we had to move, and how far, how our vehicles were

built and—especially—powered. He wanted to know what it was like to have so many people wasting so much time getting from one place to another.

I told him, in the graphic detail that only someone who has spent years fighting a daily commute and periodic air travel can, with some passion and eloquence, I might suggest.

"It would seem that humans have great need of matter projectors," he said after I had carried on for an hour.

I bit off a quick affirmative. Yes, we could use them. But...

I started to think. Three years back, we didn't know that there were any other sentients, anywhere in the Universe. We didn't even know—*know*—that there were other planets capable of supporting life as we knew it. Then the elvirti arrived. Elvirti technology is only now beginning to appear on Earth. It's not just a matter of them saying "here it is." Even if there were no technological leaps involved in, for instance, the construction of hyperspace-drive ships like the elvirti far-doubles, we couldn't immediately start building ships to take us to the stars. Ships that size have to be built *in* space. That means more than the puny little space stations we had put up before the elvirti arrived. And before we can do that, we need bigger more economical surface-to-orbit lift capability. And before we can... Anyway, that gives you an idea of what was going through my head.

It seemed that Rava-Tonnni 2-4-1 was about to offer us a workable, proven teleportation system. I suspected that this technology might be

at least as difficult for us to realize as the other.

Something else came to mind. I thought about the elvirti and their long ranging around the Galaxy. In all that space, they had only found two other sentient species... that survived. But they had also found the remains of four civilizations that had perished—self-destructed, one way or another.

I'm not sure how long I spent in my musings. After a time, whatever it was, I became aware of the camsofetu making that clicking noise in his throat, repeatedly. I looked up, and he was blinking up a storm as well. Both stopped when he saw that he had my attention.

"You do not say yes without thought," he said.

I nodded slowly. "Perhaps you can imagine what I have been thinking," I said, scarcely above a whisper.

"You worry about the assimilation of so much that is new, of upheavals, of necessary delays while people know what is possible, what is coming, but that they cannot yet realize those potentials."

I nodded again. "I don't think that we can turn away from knowledge," I said. I was speaking very slowly by that time, with the mental images continuing to assault my mind even as I spoke. "But I don't know if we dare accept it, either." I looked at Rava-Tonni, then at Captain Taemon, then back to the camsofetu. For a moment, I closed my eyes and struggled to avoid showing the shiver of fear that came over me.

"I keep thinking of the four races

that the elvirti found, the ones that do not survive. I fear the possibility that humans will become the fifth."

There was a long silence before Rava-Tonni spoke. "According to our friends the elvirti, there is no evidence that any of those doomed races ever found anyone else. Each stood, and fell, alone. Humans are no longer alone. The elvirti and the camsofetu stand with you now."

Captain Taemon translated that, then paused to let me know that what followed was his own.

"The camsofetu are much wiser than us."

I stared at the captain—I'm not certain, it might have been for as long as five minutes. Then I nodded, twice. It wasn't just that Rava-Tonni's words had reassured me, given me some hope that we could—somehow, assimilate all of the new technology and survive. There was something more important in what Taemon Oelievay said. *Finally*, I understood that phrase, and a lot more. Maybe for the first time, I started to feel as if we might someday really understand the elvirti and the camsofetu.

"*The camsofetu are much wiser than us*," wasn't necessarily a statement of fact, or even belief. It was a hope, a prayer. Maybe humans could never swallow that line, but we have one that works just as well. *We are not alone*.

I looked back and forth between my companions again. Neither of the others spoke. They were both staring at my face. I don't know what they saw there.

After a moment, I pulled out my

wallet and extracted a one-dollar bill. I turned it over and read three words from the banner in the eagle's mouth on the Great Seal of the United States.

"E pluribus unum."

"I do not recognize those words," Captain Taemon said.

"From many, one," I translated. "The motto of the United States. The language is Latin."

Captain Taemon nodded his head

twice, after he made the translation for Rava-Tonni. And the camsofetu made that clicking sound again, once, very forcefully.

We looked around at each other, knowing that—at least for that precise moment—we shared the same thought, that none of us would ever be aliens again.

It might be our only real chance. ■

IN TIMES TO COME

"The Last Plague" may sound like an ominous title, and our April cover novella, by Gregory Bennett, does indeed portray a grim situation. On the other hand, there's more than one way to respond to a grim situation (and, for that matter, more than one way to interpret that title). Mankind is, after all, a pretty resilient creature—or at least *some* of us are. I think you'll like the folks in this story and what they do with the mess they've been handed. One of the peculiar things about technology is that you never really know what will eventually prove useful, or how. . . .

Geoffrey A. Landis will also be back, with a distinctly original and neatly crafted Sherlock Holmes pastiche. And the fact article offers a fresh look at the prospects for terraforming Mars, by Robert M. Zubrin and Christopher P. McKay, who argue convincingly that that task may not have to be as hard, or as slow, as most people assume.

G. David Nordley

QUANTIZED SURFACE GRAVITY?!

Something strange is at work in the Solar System. The distribution of the surface gravities of the larger bodies in the Solar System appears, for no apparent reason, to be quantized. By quantized, I mean that the values fall

very near certain regular, discrete values generated by an integer ($n = -1, 0, 1, 2, 3, 4$) in a simple power law, as shown in Table 1 below.

Surface gravity is the acceleration that a test mass would experience

Table 1. Observed and Predicted Surface Gravities

class (n)	Name	Mass (kg)	Radius (km)	g_{obs}^a (m/s ²)	g_{pred}^b (m/s ²)	diff.
4	Jupiter	1.9E27	71400	24.87	24.57	-1.2%
3	Neptune	1.02E26	24764	11.1	9.946	-11.6%
3	Saturn	5.69E26	60330	10.43	9.946	-4.9%
3	Earth	5.98E24	6378	9.808	9.946	+1.4%
3	Uranus	8.68E25	25559	8.865	9.946	+10.9%
3	Venus	4.87E24	6052	8.871	9.946	+10.8%
2	Mars	6.42E23	3398	3.71	4.027	+7.9%
2	Mercury	3.3E23	2439	3.701	4.027	+8.1%
1	Io	8.89E22	1820	1.791	1.63	-9.8%
1	Moon	7.35E22	1738	1.623	1.63	+0.4%
1	Ganymede	1.48E23	2640	1.417	1.63	+13.1%
1	Titan	1.35E23	2575	1.358	1.63	+16.7%
1	Europa	4.79E22	1565	1.305	1.63	+19.9%
1	Callisto	1.08E23	2420	1.23	1.63	+24.5%
0	Triton	2.14E22	1350	0.783	0.66	-18.7%
0	Pluto	1.29E22	1150	0.651	0.66	+1.4%
-1	Titania	3.48E21	790	0.372	0.267	-39.2%
-1	Oberon	3.03E21	760	0.35	0.267	-31.0%
-1	Charon	1.77E21	595	0.334	0.267	-24.8%
-1	Rhea	2.49E21	765	0.284	0.267	-6.2%
-1	Umbriel	1.33E21	585	0.259	0.267	+3.0%
-1	Ariel	1.26E21	580	0.25	0.267	+6.5%
-1	Iapetus	1.88E21	730	0.235	0.267	+11.9%
-1	Dione	1.05E21	560	0.223	0.267	+16.4%

a. $g_{\text{observed}} = GM/R^2$ where values for M and R are taken from *Moons and Planets, Third Edition* by W.K. Hartmann. Calculations do not take into account flattening of the larger planets.

b. $g_{\text{predicted}} = g_0 D^n$ where $g_0 = .66 \text{ m/s}^2$ and $D = 2.47$

Quantized Surface Gravity?!

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near the surface of a given body, or more simply, how much one would weigh per unit mass on that body. A kilogram of mass on Earth weighs about 9.8 Newtons (one “gee”), on Mars 3.7, and on Jupiter about 25 (depending on where you define Jupiter’s surface to be). See the box at the end of the article for how to calculate surface gravity.

The quantization of surface gravity is strange because surface gravity is an accident of the mass and radius of astronomical objects, and intuitively ought to be spread continuously across the range of Solar System objects, rather than prefer certain values.

It is significant because, if the relationship holds true outside the Solar System, it would mean that future space explorers would find moons and planets with surface gravities like those of Jupiter, Earth, Mars and so on, but not in between. That, in turn, might mean that Earth-like worlds are more common than previously expected.

Let’s start by noting, as many other people must have noted, that there is a statistically embarrassing number (over half!) of planets in the Solar System where you would weigh just about as much as you do on Earth—namely Venus, Saturn, Uranus and Neptune.

Saturn is a big windbag, less dense than water, but still 95 times as heavy as Earth. Uranus and Neptune are more like smaller Jupiters than like Saturn or Earth and Venus. Why should planets so different have similar surface gravities?

Odd, but it gets odder. Notice that Mars and Mercury have the same surface gravity, about 38% of Earth. Why the same? Mars is almost twice as massive, but made of less dense stuff. Mercury seems more like Earth or Venus in composition.

What is really surprising, though, is that the surface gravities of Mars and Mercury differ from the surface gravity of Earth by the *same factor*, 2.5, that Earth differs from Jupiter.

Mentally trembling, one divides that 38% by 2.5 and gets 16%: the Moon. Also, within about 20% of the Moon, the Galilean satellites of Jupiter and Saturn’s big moon, Titan.

Divide by 2.5 again. One gets 6.4% of Earth: Pluto and Triton.

Divide by 2.5 again and get 2.5%, which is close for most of the remaining moons heavier than 10^{21} kg. The fit down at this mass level isn’t as good and I didn’t take it any further down. For one reason, the data on masses out there isn’t very good, though the Voyager photographs produced good radius values.

So. If one lists the surface gravities of the 24 largest planets and moons in the Solar System, they appear to cluster around certain values (see Table 1). These values of g can be predicted to a surprising degree of accuracy by a simple equation:

$$g = g_0 D^n$$

where g is the surface gravity of the object, g_0 and D are fitting parameters, and n is an integer. If g_0 is 0.66 m/s^2 and D is 2.47, the formula generates values that are generally within $\pm 20\%$ of the observed surface gravities calculated from the 24 object

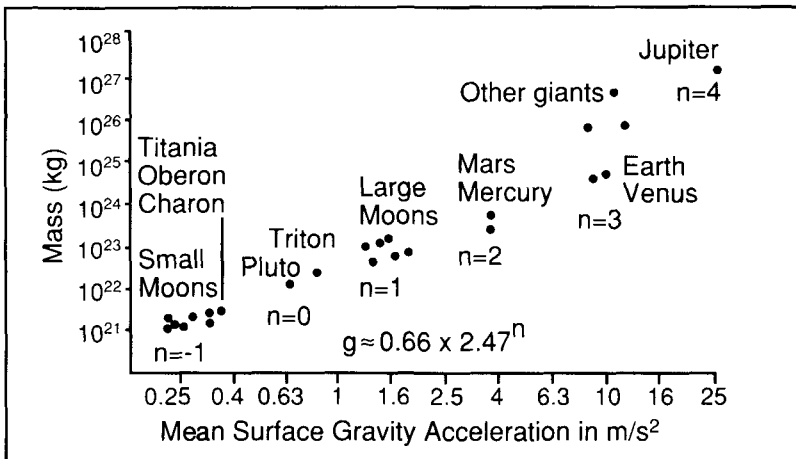


Figure 1. Mass and Surface Gravity of Large Solar System Objects.

data set I used. The surface gravity of one is 40% higher than predicted, one is 30% higher, and the rest are within 25%. Sixteen surface gravities fall within 15% of the prediction. And remember that the predicted values differ from each other by 250%!

I'll leave it to the learned statisticians to sort out the chi square confidence levels and so on in these statistics, but this clustering is readily apparent in Figure 1, and one doesn't have to remove any outlying data points to see it.

What's going on here? This may simply be the mother of all numerical coincidences, something like Bode's law. Or it may have some physical significance that helps constrain the various theories of large body accretion.

If forced, one might speculate that these values of g may be "strange attractors," or preferred results in some chaotic system of gravitational and collisional interactions. It has been found, for instance, that asteroids

prefer spin periods of about six hours, and one can build a collisional model that predicts this.

But let me emphasize that I am not attempting to support any theory to explain quantized surface gravity. Rather, I am simply pointing to the distribution of the surface gravity data and asking: "What's going on here?" ■

Neglecting things like nonspherical potential terms and rotation, surface gravity of a body is given by $g = MG/R^2$, where M is the mass, G the universal gravitational constant $6.672 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$, and R the radius of the surface from the center of the Moon or planet. Note that, because different data are used in compiling such tables, your numbers may differ in the third decimal place.

Radius and Mass Data Reference:
Hartmann, William K. *Moons and Planets, Third Edition*, Wadsworth Pub. Co. Blemont, CA, 1992



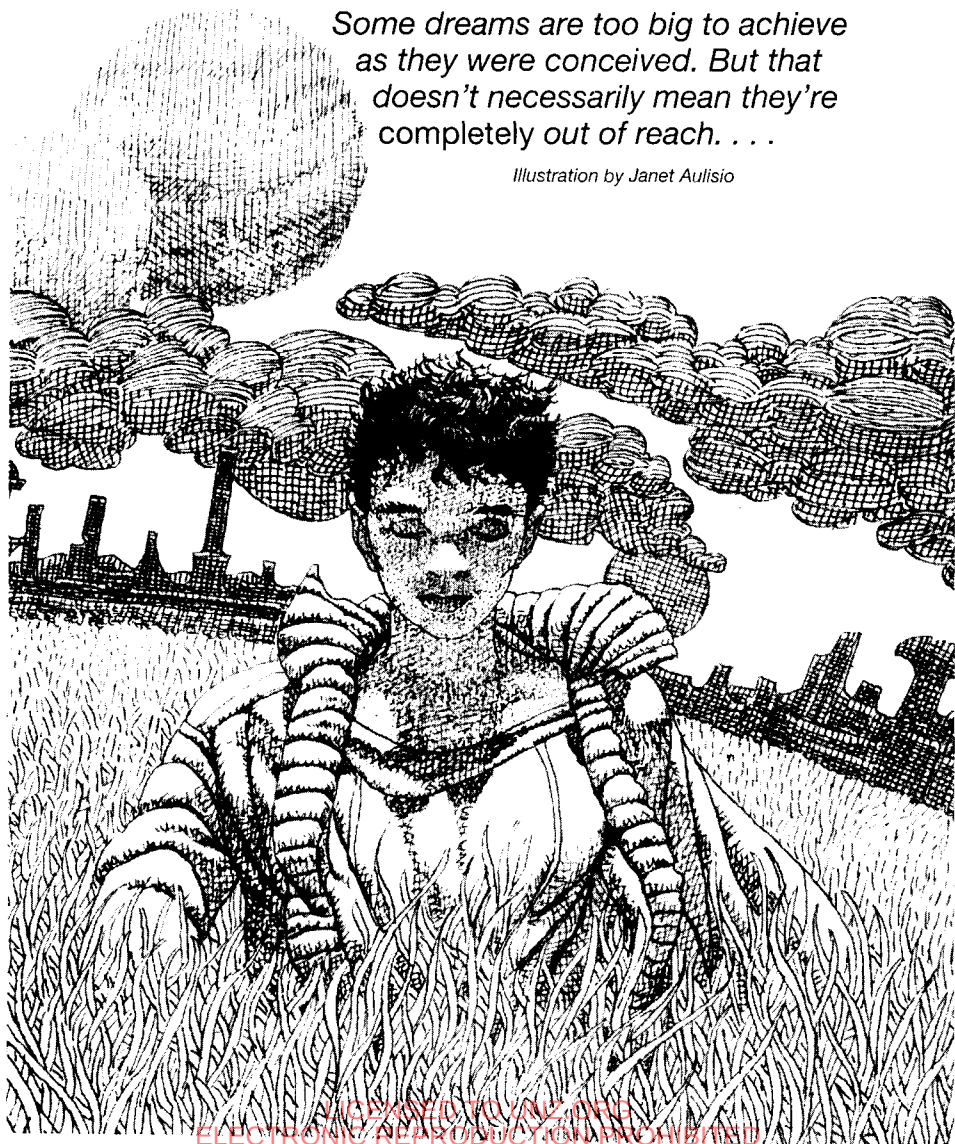
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Dave Creek

THE LOOPHOLE

*Some dreams are too big to achieve
as they were conceived. But that
doesn't necessarily mean they're
completely out of reach. . . .*

Illustration by Janet Aulisio



LICENSED TO JAZZ DRIS
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I've seen sentient whalelike creatures floating through the hydrogen, helium, and ammonia of Jupiter's skies; beings without technology whose immense intellects may have turned inward to philosophical discussions that would shame Aristotle or John Locke. I've visited an alien world called the Earth. I've known moments of supreme ecstasy when I felt the Universe and I were one, and wept uncontrollably when the Universe has shown its true nature and killed without thought, without awareness.

I don't believe I was ever as astonished, though, as when my ex-lover Laney Shackleton tapped me on the shoulder on a beach in the Bahamas.

As I turned and saw those familiar chocolate features, that short-cropped hair above active brown eyes, so many emotions began to churn within me that I couldn't form a sensible thought. Sheer surprise was dominant; she was the last person I expected to see here. For one thing, she was supposed to be half a world away. Laney was head researcher on a human hibernation project at the Tokyo Space Institute. I'd heard things hadn't been going well for that project. More pain for Laney, to add to what I'd given her two years before when I broke off with her. More guilt for me.

That was the other reason I wouldn't have expected to see her. I couldn't imagine she'd ever want to see me again. Things were pretty bitter between us there at the end.

Here she was, though, which meant she had gone to a lot of trouble to find me. I was taking my first real

vacation in many years, and I wanted to be alone, without the press or politicians or hangers-on or curiosity seekers bothering me. Few people knew where I was, and I had used my political clout and technical know-how to keep my location pretty secure even on DataNet, which is tough to do. That meant Laney had called in a lot of favors just to find me—then gone to the trouble of hopping on the Miami Clipper for the two-hour trip from Tokyo to catch the local shuttle to get to me. Why was she here? Reconciliation? Revenge?

All those thoughts went through my brain in about three-quarters of a second, during which I was standing there in the surf, mouth agape, not looking at all like anyone's image of Alexander Barron, brave planetary explorer and media darling—first man to fly solo through the rings of Saturn, and all that.

Laney didn't speak, either. Instead, she grabbed the back of my neck, drew me down (she's rather short), and planted a long and passionate kiss on me.

"I know," she said. "What the hell am I doing here?"

"My question exactly," I sputtered.

"I take it you haven't been listening to CNN or ABC. We have a breakthrough."

"Not—a stardrive?" My obsession with the stars had been the whole problem between me and Laney. The physicists had seemed about to break the light barrier for the past two decades, but every new bit of knowledge gained had brought new problems, new technical challenges that

were beyond current technology. The more we learned, the less likely a stardrive seemed.

But I wanted the stars. I was willing to sacrifice everything for them. Even Laney. That's how much of a fool I was. She was dedicated to her own work, but she had a more balanced attitude about life.

"Oh, damn," she said, "I'm screwing this up. No, it's not a stardrive. It's nothing that will help you."

"What is it, then?"

"Cold sleep. New drugs—new hibernation techniques."

"I'd heard there wasn't any progress."

"Don't believe everything you hear."

"Come back to my cabin," I said. "You have to tell me all about this."

Soon we sat beneath azure skies on the patio of my rental cabin, with glasses of cold tea before us. I pressed Laney for more information.

"It all came out of my labs, Alex—It's so exciting! You can sleep sixty, eighty, maybe even a hundred and fifty years!"

"How can you know that, without taking that long to test?"

"The computer models all check out—extrapolating from tests where subjects have slept for three years, with only a few serious side-effects. Even if those side-effects turn out to be ten times worse, that means a possibility of losing one or two people out of a thousand—it's considered an acceptable risk."

"Then why is it nothing that can help me? Something to do with politics, I'd guess?"

"No, Alex. The cryonics—the combination of freezing and drugs—they've been tested thoroughly—thoroughly enough that they discovered anyone over thirty-five has a very poor chance of surviving. A forty-two-year old woman died—within days. It almost brought about the cancellation of the project. A forty-year-old man almost didn't make it—he was revived just in time."

I understood then. "I'm forty-eight."

Laney came to me and embraced me. "And I'm forty-five," she said. "I thought you should hear it from me, Alex. The stars will never be ours. That dream is dead, at least for us. If you can only let it go, now, we can at least have each other again. Forever this time."

My first encounter with an inhabited alien world was when I turned twelve. My dad shuttled me down from Von Braun Station to the most wondrous place in the solar system, a world virtually covered with the most precious substance known to humanity—water. I quickly fell in love with the water world, ironically called "Earth."

Virtually an entire globe lay beneath us as we entered the atmosphere; the terminator was just barely visible at the edge of the planet. Earth was a planet of contrasts as stark as any in the Solar System, with browns, blues, and whites swirled together.

The Pacific Ocean was visible in its full cloud-streaked glory and vastness, proclaiming beyond doubt that although human thought and con-

cern gravitated toward the land masses first, the water-world image was more descriptive. Life had begun in those oceans, in an environment less ruled by gravity. Judged on a cosmic scale, its tenure on land would be brief. Now human beings were living in space, a weightless, unbounded environment more akin to their origins.

As we arced eastward, Dad showed me the outline of the North American continent—from Mexico and Baja, past Kansas wheat fields and the evergrowing sprawl that was Chicago (some, less charitable, called it an encroaching cancer), and into much of Canada. Farther north, the polar ice was hidden in cloud cover.

All my life, I would treasure memories of sights, sounds, and smells that immediately brought back a boyish sense of wonder. The Sun, unnaturally bright, blinding me intermittently as I walked through a forest, leaves crackling and rustling beneath my feet, a random kind of sound you never heard on an orbiting habitat.

Emergence into an open field, the landscape frighteningly flat instead of curling up securely around me.

Lying down in Kentucky bluegrass, eyes closed against the uncomfortably empty sky above. The scent of unknown and exotic flora around me told me I rested against a living thing.

Even at such a young age, even though I had been born in space, I felt an intuitive bond between myself and this planet. I felt a thrill of discovery that was forever denied to anyone born on this planet, who took her wonders for granted.

I desired even more. I wanted to see more worlds, more wonders.

And now it all came crashing down around me. Laney was sitting across from me again, her expression thoughtful. "Isn't there some—"

Laney slammed her glass down onto the table. "Stop it, Alex. You're always looking for the loophole. It's never been there. There is no stardrive. You're never going to see those alien worlds you still dream about. You've experienced more than most humans ever have in space—be thankful for that, and give up the rest."

"How can I? All my life—"

"All your life you've had a dream. You have to let it go, now. I realize that's difficult. But I've had a dream, too. Of a normal life, of a life with you—an *everyday* life, with routine and a home and children, not one driven by this irrational dream."

"Not so irrational, maybe. You've accomplished something others said was impossible—cold sleep was a discredited idea, and you've made it real."

"I guess I was lucky, Alex. I had a dream that was achievable."

"But if you refine cold sleep—or if the physicists ever do come through with a stardrive—"

This time Laney put her glass down more gently, but the effect was even more chilling. "I'd hoped you would feel differently. I'm sorry, Alex. I thought the point here was that I love you, and want to be with you. I guess this was a bad idea." She left the patio and started walking down the beach.

* * *

The years passed after that visit to Earth, and I knew more worlds—I searched for any remnants of life on Mars, even the tiniest fossil, and came away empty-handed, as every explorer there had so far.

For about a year, I worked with Maarten Ellerson, the brilliant Dutch engineer. He was working on the idea of using hollowed-out asteroids as spacecraft, perhaps even making them into starships eventually. The Dutch, it has been said, are natural ecologists, since half their population live on land reclaimed from the North Sea. Maintenance of canals and dikes, and an understanding of ecological balance, were part of their everyday life.

Tragedy struck, though, on one of the first asteroids Maarten and I studied. We landed a small shuttle on the unnamed rock, looking for structural defects that could split the asteroid apart if acceleration were applied. We bounded lightly over its four-and-a-half billion year old surface. The asteroid's gravity was insubstantial. A strong jumper could find himself orbiting it or even cast adrift.

Maarten pointed out the blue dot that was Earth in the dark infinity around us. "It's always beautiful to me," he said, "no matter how small it may seem from out here."

"I'm with you," I said. "Let's go ahead and place the drill."

Soon we had the portable drill set in position and stepped back some twenty meters. The device began its work, drilling down just a few meters into the surface of the asteroid. In a

moment it would set off the tiniest of explosive charges that would send reverberations through the giant rock. Those reverberations would be recorded by sensors within the drill, revealing the internal structure of the asteroid, without damaging it or endangering us.

The charge didn't go off on schedule, though. Maarten pressed an override control on his spacesuit that was supposed to detonate the charge in case of malfunction, but that didn't work, either.

"I'll check it out," Maarten said.

"Is the charge deactivated?" I asked.

"Yes. I just deactivated it. Confirm." Maarten showed me the read-out on his suit that indicated the charge was inert.

"Confirmed inert," I said, and watched as Maarten loped over to the drill and bent over it.

"Here's the problem," he said moments later. "The drill isn't fully extended. These chondrite asteroids are pretty solid. I'll just set it to a higher penetration level and start it up again." Maarten then backed away from the drill, but not far enough, and not in time. An explosive outburst, silent in the vacuum of space, broke the drill—and debris from the explosion shattered Maarten's faceplate and much of the right side of his face, flinging him backwards. Maarten's body tumbled over and over in the asteroid's micro-gravity, spraying blood. His body hadn't even settled to the ground by the time I made it over to him.

It was too late, of course. I knew

Maarten was dead before his body struck the ground. I realized immediately what had happened—the drill had struck a pocket of ice and vapor beneath the asteroid's surface. Such pockets were often the burned-out nucleus of a comet that had struck the asteroid and buried itself beneath the surface. When the drill hit it, the gases and ice particles would have been released all at once, with a tremendous explosive effect. That explosion also set off the charge within the drill.

I stared down at the mangled features of my friend for a long time, tears flowing freely. This wasn't how things were supposed to happen. It was all supposed to be an adventure. Yet in a single instant, a long life of exploration had ended.

I buried Maarten under a cairn of rocks. If no one else disturbs him, he'll rest there for all eternity. Since then, my dreams have been tempered with a sense of caution—and of loss. I knew then that however much I might accomplish, I would probably die with some of those dreams unfulfilled.

A couple of years after Maarten's death, I arrived at Callisto Base to pilot the first missions into Jupiter's atmosphere to try to understand the beings that lived there.

The very first time I met Laney, I thought I might fall in love with her.

She was a biologist, second in command at the base, and commander of the exploratory missions. I first noticed her eyes as we shook hands. They seemed to take me in at a single

glance, to understand everything there was to know about me. Thankfully, she seemed to approve of what she saw. "Glad to meet you, Captain Barron. I'm Elaine Shackleton. I've heard a lot about you."

"Please—I'm Alex."

"Great. Then I'm Laney."

"I hope you've only heard the good things about me."

Her smile was wide and radiant, with a hint of mischievousness. "I'll find out if everyone's been telling the truth. You ready for a test run?"

I was taken aback. "Uh—sure. Where?"

"Oh, nowhere in particular. Just a little jaunt."

That "little jaunt" turned out to be a harrowing push-the-envelope flight in a small shuttlecraft just above Callisto's cratered, gray surface, with Laney showing me her favorite features—at about six hundred KPH, and seven meters off the deck. Callisto's surface was laced with ridges and cracks—the result of meteor impacts or cracks in its icy crust, which was nearly a hundred kilometers thick. After about fifteen minutes of the tour of the moon, Laney said, "I'm being unfair," and smiled as she punched the buttons that handed control of the craft over to my co-pilot's position. "I've flown over these same features so many times, I know them by heart. Let's see what you can do, now."

As intimidated as this unexpected challenge—and Laney's skill—had made me at first, I liked this woman so much I couldn't be offended. I managed a no-doubt goofy grin and took the controls. "Hold on," I said,

then took the shuttle into a steep climb and arced it over toward Callisto's northern hemisphere and its largest surface feature, a circular basin three thousand kilometers across called Valhalla.

Within ten minutes I had tilted the shuttle on its side and was flying it in a circle around the edge of that basin—a much more difficult maneuver than if we were in an atmosphere, in a winged craft. I kept only about ten meters from the basin walls as I took us lower and lower, the circle ever-tightening as we flew closer to the bottom. As I forced us into smaller, lower circuits, centrifugal force pressed us into our seats.

Finally I programmed an auto-sequence into the shuttle's propulsion system, and activated it. The craft twisted around toward the center of the basin, then shot straight up, accelerating so powerfully that Laney and I blacked out.

When I revived, I checked all systems—we were flying free, away from Callisto and any of the usual space lanes Callisto Base had established. Just as I had intended. Then I looked over at Laney, who had apparently awakened first. "Well," she said, "you've got the job—if you didn't kill us back there, you'll be pretty safe on any mission I can dream up."

Our "little jaunt" was the talk of Callisto Base that night, as a dozen of us sat around the base's commons drinking contraband bourbon someone had broken out for the occasion. But as the others spoke of vectors and fuel consumption rates, Laney and I traded smiles. There were still eight

or nine people in the commons as Laney and I slipped away to her quarters to make love. She was as adventurous a lover as she was a pilot, and quite agile in Callisto's low gravity, just over a tenth of a *g*.

We began our first mission into Jupiter's clouds about a month later.

I've never believed in God; but I believe in Creation. It never fails to astonish. The discovery of life swimming in Jupiter's atmosphere—the largest life-forms in the Solar System, dwarfing even Earth's blue whales or the long-dead dinosaurs—had captured the entire system's imagination.

As we hurtled through the giant planet's clouds of hydrogen, helium, and ammonia, our sensors strained to detect the electrical impulses the great beasts, some half a kilometer in length, used as their language. It was a difficult task to obtain a clear signal against the static Jupiter's own magnetic field generated. The "experts" (to use the term loosely) believed their language was even more complex than that of Earth's whales. Although we found evidence that they used language to sound warnings or make course changes in a herd, much of what they sounded had no practical meaning we could discern. Laney and others believed much of their meaning was cultural or intellectual. After all, they were in much the same position as Earth's whales—without manipulative organs or a way to create fire, they could not become a technological species. Such intelligence must find outlets somewhere, and what better ones than music or philosophy?

Deciphering that language fully, not to mention attempting to understand the culture of beings the size of houses who lived neither on land nor in seas would be the work of a lifetime. Somebody else's lifetime, not mine. I was merely a willing witness, content to remain in awe of the patient mental processes of the creatures who lived in Jupiter's skies.

The day those missions ended, Laney and I shared a drink in the commons at Callisto Base. I asked her, "What's next for you?"

"I don't know. I'm being considered to head the cold sleep research group on Earth, but the funding may not be there."

"I suppose stardrive is a dead issue."

"You suppose correctly."

I stared into my drink. "And what about me?"

Laney took both my hands into hers. "I'd like to be wherever you are. We share the same dream. I know that."

I nodded. "I'll wait with you—to see what happens with that position on Earth. I'll find a way for us to work together—we can go to the stars together."

By then I was pushing forty, and impatient for the stardrive breakthrough. It hadn't come, and didn't seem to be on the horizon. The U.N. Space Council was about to cut funding for star travel. Something had to be done quickly, to convince them it was vital to proceed with a starfaring project even if it meant doing it without a stardrive.

By then, my exploits had made me

somewhat of a cult figure for a romance-hungry populace; I was willing to use that notoriety shamelessly. I had to return to Earth quickly, but without letting on I was coming—in the weeks my journey from Callisto Base would take, too much support against me might be mustered.

I remembered: the return in secret to the water world that had so sparked my imagination in my youth; the surprise appearance as spacer spokesman before the U.N. General Assembly; the subsequent approval of funding to continue the stardrive research. It was an act of desperation, but it was worth it. Laney found herself head of the cold sleep project.

But the cold sleep project didn't need me. And I realized I wasn't ready to become an Earther, a flatlander full-time. I wanted to keep working in space. I did—that was when I took that unauthorized trip through Saturn's rings, for instance—but I kept thinking of Laney. When I took that vacation in the Bahamas, I spent half my days wondering whether I should try to contact her. Then she tapped me on the shoulder as I walked down that beach. In my cabin, when we began to argue and Laney started back down the beach, naturally I ran after her. I'm not a total fool. We were married two weeks later.

I looked at Laney's profile, her features barely visible in starlight and the glow from a crescent moon. The years had added a few lines and wrinkles and gray hairs, but she was more beautiful to me now than ever. "Chilly out here in this field," she

said, looking into the clear skies.

I bent closer to the video monitor that received its picture from the portable telescope we had set up in the broad field behind our Florida beachfront home. Laney had moved into new research facilities here to be closer to scientists working closely on the first star mission. "I like the cold," I said. "I like being outdoors. It still seems like a new experience to me. It reminds me of when my father brought me here as a child."

The sun, unnaturally bright—the landscape frighteningly flat—eyes closed against the uncomfortably empty sky above.

"Can't you see the ship yet?" Laney asked. "Maybe the kids had the right idea, watching on the cube."

"There it is! Just barely. This isn't the optimum instrument for this, you know."

Laney looked. "It's still magnificent." The *Goddard* was a glorious sliver of light in the center of the monitor.

"Look quickly. It'll only be visible a moment before it goes out of frame. I can't be sure I'll be able to follow it. We need to buy a newer 'scope, one that tracks on its own."

"Oh, shush. It's still magical enough, isn't it? A pretty good payoff for twelve years of work."

"Those years have passed quickly," I said. I looked toward the heavens. "I envy the starfarers so much."

"They have good reason to envy you. You were the father of all this. And you'll be here to find out what they've discovered."

"We'll be here. That's the im-

portant part."

Laney and I fought again after that day in the Bahamas—but there was never any question that we wouldn't be staying together to continue our battles. The Earth, after all, really is still an alien world to me. The Sistine Chapel and the Great Wall must surely be as wondrous as any alien artifacts.

Still, it's tough to stand out beneath the night sky and not look upward and wonder. What other beings are hidden out there on unseen worlds circling the stars? What physical laws have they discovered that we have not? What insights about life and death and love and God? What do they look like? Are the cat and lizard people and tentacled monstrosities of science fiction too bound to human ideas of biological development? Will we discover whole new categories of life when we find it out there—life not mammalian, nor reptilian, nor insectile, nor any other Earth type, but something utterly new and unanticipated?

I still wonder about such things, but the answers, if any, must still wait decades to be revealed. They may never be revealed, at least not during my lifetime.

I never did find my loophole. But I would be part of the first star mission in a small way, working volunteer shifts in Mission Control here, monitoring the sleeping starfarers, waiting for the *Goddard* to arrive in the Alpha Centauri system. I'm sixty now. If I'm lucky, I'll live to be a hundred, about the time the *Goddard's* crew awakens from their cold sleep and their first messages arrive.

Then the *Goddard's* burn started. Laney and I looked upward—the ship's flare could now be seen with the naked eye. Even when its initial burn ended, it would still be visible to our 'scope, an ever-fainter star, a beacon of hope.

For me, a reminder of what could never be. I was luckier than many, however. I had Laney, and two beautiful daughters. I had seen magnificence most humans only dreamed of and if I wanted more, that only meant

that humanity could never rest until all the Universe's secrets had been revealed. We could never be satisfied. I had discovered my share. Now it was time for others to take over.

I packed the telescope away and Laney and I ran down to the ocean and splashed each other in the surf, laughing and running like children.

After awhile, exhausted, we left the water and collapsed onto the sand, as if we were new life that had just crawled up from the sea. ■

Research is comprised of glimpses, through moving clouds and smudge, which are caught and gathered together to become a complete jigsaw puzzle perception which seems to fit the rest of provisional knowledge. For people whose interest it catches, as entertainment, research activity cannot be surpassed.

Murray Young

Having it all doesn't necessarily mean having it all at once.

Stephanie Luetkehans

THE BANDWIDTH REVOLUTION: INTERNET AND WORLDWIDEBEB

Technological revolutions are often visible well before they arrive. We knew, for example, that transistors and computers were going to become important long before they had any actual impact on society. But other revolutions can sneak up on you. Without my noticing, various minicomputers were linked over commercial telephone lines and satellite links to form a computer network, and one day, without even asking for it, I was able to send E-Mail from my VAX to other computers across the continent and the world. A bit later digital scanning and telephone modem technology matured, and suddenly fax machines were everywhere.

Well, it's happened again. About six months ago I discovered the World-WideWeb (WWW) hypertext system for Internet, a system that allows access to distant computers with almost magical ease. As of about a week ago (8/93) the UNIX workstation in my office became a "server" on WWW. I'll explain in more detail later, but essentially it puts me in the elec-

tronic publishing business. I can place illustrated reports, formatted papers with figures, drawings, maps, technical manuals, slides from my recent vacation, pictures of my children, my latest short story ... in files on my computer, and instantly they become accessible to anyone on the planet with suitable hardware, network connections, and software. I can access similar electronic documents elsewhere, fetching beautiful astronomical pictures of Supernova 1987A or the Ring Nebula from NASA Goddard, taking a tour of a special exhibit of medieval documents from the Vatican Museum courtesy of the Smithsonian, examining weather maps, satellite pictures, and even viewing movies of changing Pacific weather patterns supplied by a server in Australia, or fetching a software manual from CERN in Switzerland.

What happened? Well, the Internet happened, the clever network specialists and programmers have now devised remarkably effective and painless ways of using the Internet and the bandwidth behind it to work

electronic miracles. To explain what has been going on in this area, let me use a question-and-answer format.

Q: *What is Bandwidth?*

A: "Bandwidth" in its narrow engineering definition, is the permissible frequency change that can be made in a selected "carrier frequency" in order to transmit information. For instance, an FM station that is broadcasting at 100.5 MHz (million cycles per second) is permitted to vary that central frequency up or down by about 100 kHz (thousand cycles per second) to send its music and speech. The stations are carefully spaced over the FM band so that the bandwidth of one station does not overlap that of stations on neighboring frequencies.

The more general meaning of bandwidth, as it is now entering our everyday speech, is the rate at which information can be transmitted over a given medium (telephone cables, cable TV, microwave relays, fiber optics, satellite links, etc.). In general the permissible bandwidth, for both regulatory and technical reasons, is about 0.1% to 1% of the carrier frequency. This means that the available bandwidth grows with the carrier frequency. Thus the higher the frequency, the greater the volume of information that can be transmitted. Similarly, if there are several transmission paths, more information can be sent and so the effective bandwidth is increased. Below I include references to a couple of recent articles by George Guilder that discuss the virtues of new-found bandwidth.

Q: *Why is there a bandwidth revolution?*

A: We think of microelectronics as dropping rapidly in price. But, as a scarce commodity, bandwidth is dropping in price even faster. There are several reasons for this. First, the transmission media are becoming faster. The twisted pairs of copper wires in telephone lines are being replaced by coaxial cables and fiber optic cables capable of operating at far higher carrier frequencies. The electronic circuits that process the information at each end are also speeding up. A second reason is that, because of the availability of very inexpensive fast computing, the transferred information can be "compressed" at the transmitter and "decompressed" at the receiver, thereby requiring a factor of 2 to 10 less bandwidth for a given rate of information transfer. The third reason for the increasing availability of bandwidth is the networking of computers by high-speed land-based lines and satellite links.

Q: *How can networking computers create bandwidth?*

A: Each computer in the net is linked to several other computers, producing a multiplicity of possible paths between any pair of computers in the net. Information at the transmitting computer site is broken up into "packets," each with its own addressing and "checksum" consistency information. These packets are passed to other computers to which the originator is linked, and these in turn compute a best path for each packet and pass it on to the next computer in the net. The computer at the receiving end reassembles the packets, verifies the checksums to detect

transmission errors, requests retransmission of packets when errors are detected, and acknowledges receipt of the information. To the user this breakup, reassembly, checking, and handshaking is invisible. But while the requirement for bandwidth increases roughly as the number of computers in the net, the number of possible transmission paths and thus the available bandwidth grows geometrically as the number of computers in the net increases. Thus, networked computers are not so much consumers as *generators* of bandwidth.

And the network is growing. Four years ago, only 7% of the personal computers in this country were linked in a network. Today, two-thirds of them are networked, with many local area networks also linked to the Internet system.

Q: *Where did the Internet come from?*

A: In the mid-1960s the Defense Advanced Research Projects Agency (DARPA) was funding many high-tech projects that required large and expensive mainframe computers. Someone in the agency, noting the vast sums of money being spent on computer hardware that stood idle part of the time, had the bright idea that if these computers could be linked, i.e., tied together in a network, the available computing resources could be shared more efficiently and the overall cost per compute cycle could be reduced (or at least kept within tolerable limits). And so DARPA funded the development of the hardware, protocols, and soft-

ware necessary to link these mainframes, and ARPA Net was born.

As ARPA Net grew and evolved, its users came to realize that sharing compute cycles was not really as important as some of the other capabilities that had become available. By carefully and rather tediously specifying a route through the maze of linked computers, information in the forms of programs, data files, and even personal messages could be routed electronically through ARPA Net from one computer to another. E-Mail was born, and soon after, the drudgery of path finding was assumed by the computers themselves.

In 1983 ARPA Net went civilian, and the Internet was created, adopting in the process the new TCP/IP networking standard to facilitate information transfer. Internet has been growing explosively ever since. In 1981 some 281 computers, most in the USA, were linked by ARPA Net. In 1992 more than 1.1 million computers all over the world with 4.7 million users were linked by Internet. The increase in Internet linked computers is between 15% and 30% per month. If this growth rate were to persist to the end of this decade, the entire population of the planet would be linked through Internet by about 2001.

Q: *Who pays for Internet?*

A: At my laboratory all the costs for Internet and the associated communications lines are paid for by the University of Washington. I'm not sure what the fees are, but they are small enough that I have not heard complaints from our administration. Busi-

nesses link to Internet the same way, by leasing lines and paying hookup fees. The costs of high-bandwidth connections are high enough that few private individuals can afford Internet hookups except by voice telephone modem to commercial or university nodes. However, this may change. The telephone companies, cable TV suppliers, and cellular telephone networks all have plans for delivering high-bandwidth links to your doorstep in the next few years.

Q: What can you do on Internet?

A: In my experience there are five capabilities provided by Internet that are very useful. The "Telnet" protocol allows remote log-in access to any Internet-linked computer (if you have an account), perhaps logging into a computer on the other side of the planet as if it were in the next room. The "FTP" file transfer protocol allows high-speed sending and fetching of files to and from remote computers, often accessing files even when you do not have an account on the system. Because of the bandwidth available on Internet, an FTP file transfer takes only about 1% of the time that would be required to transfer the same file by 2400 baud modem over voice telephone lines with standard "kermit" protocol. Internet E-mail allows the sending of messages (and also data or program files) to any user on any Internet-linked system, provided you know that user's E-mail address (e.g., john-doe@big.corp.com). Internet News is another feature of the Internet system, with hundreds of "interest groups" within which participants

swap opinions and information about the subject of interest, be it "sci.phys" or "alt.sex.kinky." Be warned, however, that reading Internet News can become a full-time activity, since an active interest group can generate hundreds of new messages each day. (Cramer's Corollary of Sturgeon's Law is that on most of Internet News, 99% of everything is crap.) Finally, the Internet system offers extremely powerful UNIX oriented multi-media transfer protocols like WorldWideWeb (and also the older protocols Gopher and WAIS, which will not be discussed here).

Q: What is WorldWideWeb?

A: WorldWideWeb is a distributed hypertext system that accesses information on Internet-linked computer servers all over the planet, welding these resources into a unified navigation and information access system that can present to the user formatted text, data, sound, high-quality graphics, and digital movies. The system was conceived by Tim Berners-Lee at the CERN Laboratory in Geneva, Switzerland. It was originally invented as a method of sharing data, reports, and information among groups participating in the same CERN-based particle physics experiments. But WWW has far outgrown its particle physics roots, to the extent that today only a small fraction of the information on WWW is concerned with particle physics.

What is it like? Imagine something resembling a full-color HyperCard stack operating on a Macintosh, except that the "cards" of the stack are actually files stored on a thousand

computers all over the world and the computer platform used is a powerful UNIX workstation with high-resolution color graphics, good quality sound, and an Internet connection. The WWW "card" that appears on my X-terminal screen is formatted text in a very readable type font (New Century Schoolbook), punctuated with mnemonic icons and postage-stamp-size graphics, all in a scrollable X-window field. Across the top of the window are fields providing the title of the card and its network address. Here and there in the text are icons, words, and phrases shown in blue or red. These are "anchors," active spots that, with a click of the mouse, can change the display by replacing the present card (actually a text file written using the HTML hypertext formatting language) with another card. The new card could reside in the same directory of the same computer or it could be fetched from another computer anywhere on Internet where a WWW server is operating.

The "home" card for the WWW system at my laboratory provides 29

different anchors to information resources, graphics, and other WWW sites. The network address of our system at the University of Washington Nuclear Physics Laboratory in Seattle is: "http://mist.npl.washington.edu:80/home_npl.html". You are invited to try it, particularly if you have a system on Internet that can run X-Mosaic, an excellent WWW "browser" developed at the University of Illinois National Center for Supercomputer Applications (net address: "ftp.nesa.uiuc.edu", X-Mosaic available by anonymous FTP.).

We are in the midst of a revolution that is changing the way we communicate and organize our work and our leisure. The end result of this revolution is nowhere in sight. It may come to resemble "cyberspace," but in its present form it is very different. In the next few years the computer in your home, your workplace, and your briefcase will be linked at high bandwidth to Internet and WWW (or their successors). And the world will be a very different place. ■

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Hayford Peirce
**TO CHANGE
A MEMORY**

*Any tool that can be used to do
great good can also be used to do
great harm—and vice versa.*

Illustration by Janet Aulisio

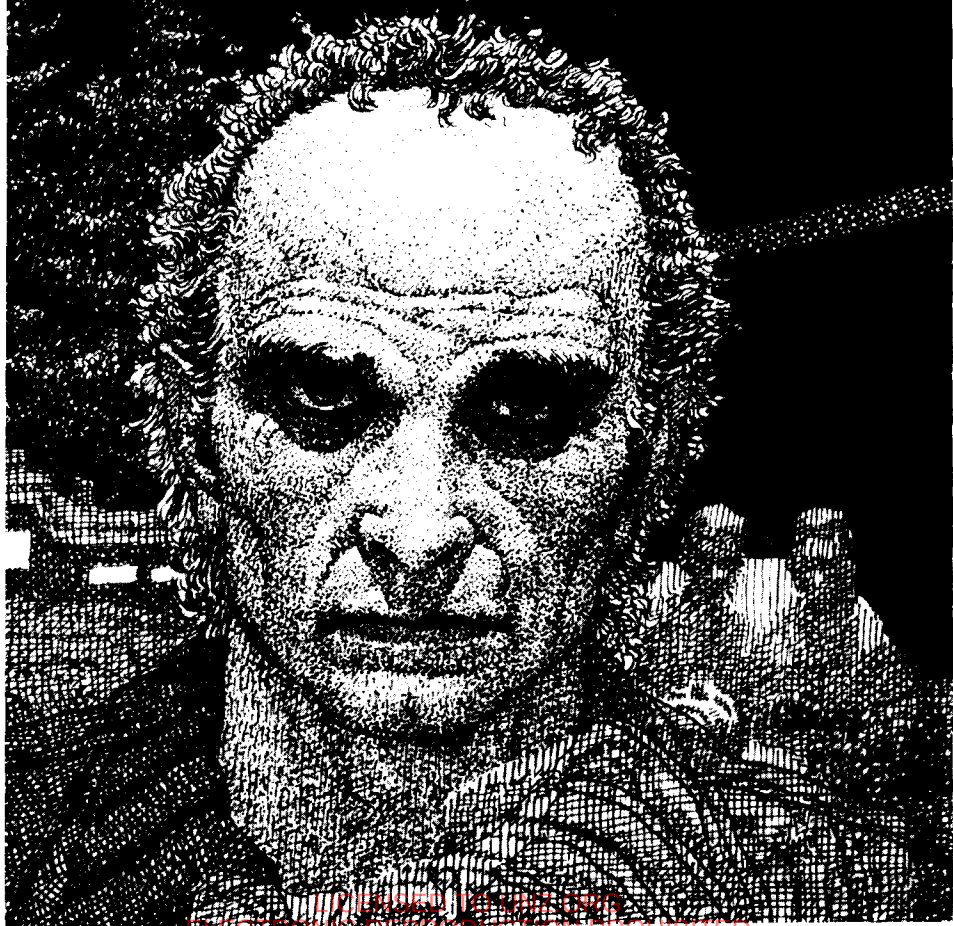


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Sam Ferron watched with glacial blue eyes as Alvin Ashley Douglas was strapped to a gurney in the infirmary of Leavenworth Federal Prison. A drip tube was inserted in a scarred vein on the prisoner's left wrist. A man in black mumbled a few words from a tattered black book. Clear liquid began to run through the tube that led down from the drip bag. Twelve minutes later a wall monitor showed that the prisoner's brain patterns had flattened and stopped.

Ferron glanced down at the digital display on his wristphone. It showed 11:06:43 P.M. Tuesday, October 17, 2056. He nodded in somber satisfaction. At this precise moment, in the seventeenth year of the Great Sweep, the last painluster in North America had been officially pronounced dead. His quest was finally over. He should, he knew, be jubilant. Instead he felt drained and empty. He turned away from the corpse on the gurney. His enemies had deserted him. What was he going to do with the rest of his life?

Ten minutes later Sam stood in the chill night air outside the prison. A battery of reporters thrust microphones at him.

"Now that organized painlusters have been eradicated, are you going to support the passage of the 32nd Amendment abolishing the death penalty?"

Sam squinted irritably at the lights in his eyes. "I haven't made up my mind yet."

"So you don't agree with your daughter's activities?"

"Don't try to put words in my

mouth. My daughter runs her own life. I may not agree with her, but I always support her."

"What about DEPLORE? Are you shutting it down?"

"I don't know yet. I'll let you know when I do." Sam brushed past the reporters and limped to his car. Two decades before he had lost his left foot to painlusters; the stump always seemed to ache when he attended an execution.

He sat behind the wheel without making any move to drive home. For the first time in years he had no precise idea of what he was going to do next. The thought of returning to his empty apartment in Kansas City was unspeakably depressing.

Samuel Garraty Ferron was forty-eight years old and looked it, a muscular, broad-shouldered man of middle height with a deeply lined face, weary eyes, and a fringe of tight gray curls that had once been red. His wife had died at the hands of painlusters twenty years earlier; since then he had neither remarried nor sought the company of women.

For seventeen years he had dedicated himself to a single-minded mission—to rid the world of the sadistic groups of painlusters that had flourished like evil weeds during the '20s and '30s. Now the painculcs had been exterminated like the vermin they were and Sam sadly realized how little else he had in life. He came to a decision.

"Peace be with you," he said aloud to the car's security system, although these days there was scant need of one: auto theft was almost nonexistent.

tent: three convictions called for a mandatory death penalty. The engine hummed softly. "Take me to the airport," he ordered, rubbing his ankle and the joint of his artificial foot.

For twenty years Sam had little to do with women—except for one: his daughter, Emily.

The Sunny and Harmony Hallowell Trauma Center had been named after Emily's grandparents, eccentric but inoffensive people who had met the same horrible fate as Emily's mother. It was their money that had allowed Emily to open the clinic on the shores of Eagle Nest Lake in the mountains of northern New Mexico.

The center was a rambling collection of weathered stucco buildings nestled in the shadows of ancient evergreens. Bright morning sunlight glinted on the dark blue water as Sam stepped down from his cab under a cloudless sky and the trees rustled softly in the wind.

He was greeted with a lengthy hug by Emily, who was still glowing from the degree in psychoneurological therapy she had received the previous week from an accelerated program at the University of Utah Medical School. "Twenty-six years old and already it's my daughter the doctor," exclaimed Sam proudly, wrapping her again in his powerful embrace and feeling a hundred times better than he had ten hours earlier outside the walls of Leavenworth. "Just what a creaky old man like me needs to take care of him in his old age."

"Creaky old man, ha!" Emily stepped back to examine her father.

She was taller than Sam, with finer bones but with the same fair skin and clear blue eyes. Her hair was a deep golden brown. "You look a little ragged around the edges," she said with a fond smile, "but aside from that it's my considered professional judgment that you're good for another seven or eight decades. At least I hope you are. Now that you're through with ... well, *through*, I've got a job for you, an important one." Her smile had faded and her face was somber.

"A job? What do you mean?"

"Come. I'll show you."

As she led him past the high-ceilinged reception room with its bright Navaho tapestries, a figure even broader in the shoulders than Sam turned away from the fireplace. "Ho, there!"

"Tiger. I didn't know you were here."

"Just stopped by for a couple of days to rest the bones. You finished off your own little job last night or so I understand, but not all the hangmen are so mindful of my comfort; my own is never finished. Not until we get that amendment passed."

Sam nodded rather curtly. Tigernach was a naturalized Irishman with jet-black hair and milk-white skin who was a dozen years older than Emily. His surname was even more authentically old Gaelic than his first name; Sam had never learned to pronounce it to Tigernach's satisfaction. Sam hoped with all his heart that Emily would never marry him, but he had to admit to a reluctant admiration for the Irishman. At least he was far from being an ivory-tower

protestor—as his scarred face and battered knuckles more than proved.

None of Emily's boyfriends had ever measured up to what Sam considered his perfectly reasonable standards, but as the years passed he had gradually developed a resigned tolerance for them as they came and went. This latest one was a documentary filmmaker and semi-professional rabble-rouser who had recently won a prize of sorts at a festival in Cannes. Now he was busy filming executions across the United States as part of Emily's ever expanding campaign to abolish the death penalty; Tiger's role was to present its brutality to the American public. This had led to several pitched battles with prison officials that Sam suspected Tiger had purposely instigated. At the very least, images of him and dozens of other brawny protesters cheerfully fighting armed guards turned up in the media with surprising regularity.

Tignach bubbled with enthusiasm. "Sam, my boyo, have I got a great recording for your jaded eyes! Even a calloused old hangman like himself will chuck his cookies when he sees it. It's that hellishly botched execution of those ten youngsters in Lewiston, Maine, last Thursday night as you may recall. Screaming and crying for Mama they were, wailing and howling like a convention of banshees as the blessed hangman tried and failed to do his duty for three blessed hours, just a couple of bodies more in all the thousands of pieces of human garbage swept up by the Great Sweep."

"You're not saying they were *inno-*

cent, are you?" demanded Sam.

"Oh no, that I'm not. How could they be, with P.E.? Even I am not so daft as to say a thing like that. But even so, these were naught but children who were tried for looting a music store during a clip-clop festival and then resisting arrest. Imagine that, my gloomy old paterfamilias, eleven children put to death for stealing some clip-clop feel-mes."

"Looting's a serious crime."

"Busting some windows? Stealing some *music*? Why, twenty years ago no one would ever have dreamed of even putting them in jail! And now . . . now everybody just shrugs and says, Since we've been giving the chop to all these ungodly painlusters anyway, why not just give it again to everyone else who's too ignorant or willful to keep from troubling the peaceful sleep of the citizens?"

Sam nodded wearily, too tired to argue. He himself, he knew, was partially responsible. Without the 31st Amendment that permitted self-incrimination by subjecting suspects to interrogation by perceptualization enhancement, the death penalty would never have been reinstated for such an endless list of offenses. Interrogation by P.E. was easy, painless, and foolproof—and the guilty were infallibly separated from the innocent.

Knowing you were executing an indisputably guilty man made it far, far easier. The graphic revelations of the horrors inflicted by the thousands of painlusters and their paincults made it easier still.

But now the temper of the times

had suddenly changed: Sam knew there was widespread revulsion with the endless horrors and executions of the last decade. It was ironic, but not altogether surprising, that his own daughter was in the forefront of the movement to abolish the death penalty.

Sam shook his head. "I don't need to see your recording, Tiger. But you may be right; there may have been enough killing. I—"

"Ah, I thought I heard your voice!" Joelina Kody, the center's director, joined the group. She cocked her bird-like head and peered at Sam with narrow-set gray eyes. They twinkled with enthusiasm. "Has our marvelous new psychoneurological therapist in residence been giving you the grand tour?"

"We were on our way to see little Zhexara," said Emily heavily.

"Zhexara. Ah, a sad case, that."

Sam's heart sank at their tone of voice but he reluctantly let himself be pulled along the corridor.

Zhexara lay in a hospital bed surrounded by the same sort of equipment Sam had been so sadly familiar with fifteen years before, when it had been Emily who had spent nearly three years lying as mute as a catatonic. A nurse standing at the head of the bed looked up at them with startled fawn's eyes.

"Oh," said Emily. "I didn't know you were here, Marianna."

The nurse backed away a step. "I... I... Dr. Bodvian wants him in the clipper room. I was just—"

"That's all right, we'll go along with you. We just wanted to take a quick

look at him." Emily hesitated, glanced at Dr. Kody, then said, "By the way, Marianna, this is my father, Sam. Sam, this is Marianna, our A-number-one nurse in training. We have high, high hopes for her."

The nurse smiled hesitantly and looked down at her hands. She was an exotic looking brunette with a slim figure and large liquid eyes. Sam vaguely remembered brief glimpses of her during previous visits. Now she deftly directed the bed across the room and into the hallway.

"What's the clipper room?" asked Tigernach as they walked alongside the bed.

"The treatment room; we call it the clipper room because of the O-CLIP computer."

Sam looked down at the child in the bed. His hair was black and coarse, his skin a sallow brown. His unblinking brown eyes were fixed on the passing ceiling. He was perhaps nine years old.

"An Amazon Indian," said Dr. Kody. "One of a tribe way up near the headwaters. He's being treated for severe emotional trauma." She turned sharp eyes to Sam. "The same sort of trauma Emily went through, I'm sorry to say. He's been here six months. So far we've made no progress at all in treating him."

Sam could only nod bleakly.

Dr. Bodvian was waiting with another doctor in a room that to Sam was as instrument-laden and incomprehensible as the control center of a fusion power plant. Dr. Bodvian was still shaggy and disheveled, just as Sam had known him years before, but

considerably grayer and stouter. He attached a number of monitoring devices to the silent child, then examined his bank of instruments. "Looks like he's in fine physical shape." He nodded to Marianna, who slipped a transparent mask over the boy's nose and mouth. A moment later the boy's eyes closed.

"We've made *some* progress since you last saw all this," said Dr. Kody to Sam. "At least now we don't have to keep a catheter in him just to give him the CNS inhibitor. Now we use this aerosol mist that's just as effective and has no side effects or discomfort whatever."

They watched silently while a gleaming metal helmet was placed over the boy's head and Dr. Kody joined her colleagues at the instrument panel. Numbers and lines began to move across half a dozen brightly colored monitors. Emily nudged Sam and Tigernach toward the door. "There's nothing for us to see for the next couple of hours except for an occasional memory shot frozen up on the screen for reference. Right now they're picking through a couple of minutes of memories practically neuron by neuron." As they left, Sam felt Marianna's eyes fixed on them with unblinking intensity. He lifted his eyebrows at his daughter.

"Poor girl," said Emily, "she's still a little shy; she's had some bad problems of her own. But not so bad as that poor little boy. The Great Sweep may be over here in the States, but in other parts of the world where they don't care about niceties like perceptualization enhancement, it's still go-

ing full steam ahead whether there are any actual painlusters left or not. It gives governments and policemen a marvelous excuse to wipe out all the people they don't like. Or whose land they want." They had reached Emily's office. "Here, take a look at this M.R."

Sam knew what was coming but forced himself to watch the gruesome memory recording. It differed only in details from the one that had been recorded during his own daughter's catatonia years before. This one showed uniformed soldiers pulling screaming people from thatched houses in a jungle clearing, lining them up and shooting them down, children included.

"This," said Emily, "is how the Great Sweep is being carried out in Brazil, as seen by Zhexara. His tribal village was accused of harboring painlusters—not convicted, just accused. Actually, the local government wanted to seize their land; gold had been found nearby. He was the only one to survive. Some Quakers found him and brought him here."

Sam's eyes closed in pain as he suddenly saw before him the blood-smeared face of the little Brazilian girl lying beneath the gruesome pile of dead birds and human bodies that was all that remained of the three dozen painlusters who had killed his wife two decades before. Sam was being carried past the bodies when his eyes met the little girl's. He had thought her dead—until her eyes had blinked. And then again. She was six years old and had been brought by her parents to watch the show. . . .

It was a show that Emily also had been forced to watch, one that had thrown her into a state of catatonia that had lasted three years. If it hadn't been for Dr. Kody and her experimental techniques she might still be lying silently in a dark room somewhere.

"What we've done," Dr. Kody had said years before at a moment when Sam felt nearly incapacitated with despair, "is to take the basic concept and techniques of perceptualization enhancement one step further and link Emily into a custom-designed virtual reality system. First she's sedated, then she's fed tiny computer-controlled doses of psychoactives while we monitor her cerebral activities on practically a neuron by neuron basis. The computer prods her brain, stimulating the synapses, which produces feedback. It then translates the feedback into digits, processes the digits, and puts them up on the screen in a graphic form that we humans can understand. Once we have a clear record of her memories, we begin—very, very cautiously—to experiment with wiping clean those neural paths in Emily's brain that actually contain the memories responsible for her trauma."

"She doesn't feel anything at all—or have any kind of dreams?" asked Sam anxiously.

"Absolutely not. As I said, first we give her a neobenzodiazepine-based CNS inhibitor that totally blocks the transmission of nerve impulses across the synapses for everything except the autonomic nervous system. It's as if the brain were an engine we've

switched to neutral—there's absolutely no activity except in response to our stimuli."

It had taken three years of treatment, but at the end of that time Emily was a seemingly normal ten-year-old child, no longer the autistic creature who huddled in the dark for months without moving. One day she had awakened from normal sleep to clutch Sam's hand and tell him she had just had a beautiful dream about owls. Seventeen years later, the memory of that miraculous awakening remained the most joyously bittersweet moment of Sam's life.

"What do you know about O-CLIP computers?" asked Emily, brusquely jerking him back to the present.

"I think I heard Joelina mention them years ago, but whatever they are I've long since forgotten."

"An O-CLIP is the heart of the brain-scanning computer we use here in the clinic," said Dr. Kody, who had joined them without Sam noticing her. "In fact the heart of our entire therapeutic operation. O-CLIP stands for Optical Cell Lattice Image Processor. That means that it works entirely through light—there is no electricity involved internally. It's an optical neural-net processor that performs functions similar to those performed by an organic brain, but many millions of times faster. It translates data into binary bits and feeds them into the chip's inputs. When I first met you and Emily years ago at the Utah Med. School, we were using the latest available model, a relatively sophisticated two-dimensional design. Since then, machines using dozens of three-di-

mensional O-CLIPS tied together in parallel have been developed that theoretically are hundreds of times more intelligent than any human being—depending, of course, on your definition of intelligence. Even the restricted models available commercially are astonishingly powerful, particularly for applications within the field of artificial intelligence.”

“Clear enough—I think. And that’s what you’re using to treat your patients, just the way you treated Emily?”

“No,” said Emily fiercely, “and that’s just the trouble! The government won’t let us! You heard Joelina say the only models available are restricted ones. What we’re using here is hardly more advanced than the 2D model Joelina was using in Utah fifteen years ago.”

“I don’t understand. Why are they restricted? And how?”

The first 3-dimensional O-CLIPS, Emily explained, were just beginning to be produced in 2039 while she was being treated in Utah. In spite of what Dr. Kody may have suggested to Sam at the time, the doctors were *not* able to create a false set of memories to cover the trauma of her Hawaiian nightmare. The best they could do, using the equipment of the time, was to isolate the memories of the trip, then totally eradicate them, along with all initial memories of the medical center. That was enough to bring her back to normality.

“But that recovery could just as easily have been purely spontaneous or pure, dumb luck! It isn’t something we can count on. For instance, we’ve

made no progress at all with that poor little boy we just saw: he’s still completely autistic. And yet all his traumatizing memories have been completely erased.”

“And so?”

“And so in spite of the limitations with the technology we’re currently using, we’ve finally reached an entirely new stage. We’ve experimentally succeeded in creating brief snippets of false memories for severely traumatized patients. But it’s one thing to erase a couple of memories of a child, another thing entirely to do it in an adult. In order to function, adults *need* their adult memories. Or at least a reasonable substitution. What we urgently need is the new 3D O-CLIPS that the government has restricted.”

Sam was confused. “I thought you just said you had a 3D O-CLIP computer.”

“We do, but it’s a purposely crippled one, the only type they’ll let us have.” Emily paused for thought. “It’s... it’s as if you went out and bought yourself a sixteen-cylinder Ferrari sports car and the government made the dealer disable thirteen of its cylinders before you could take delivery. We can do work—important work—with what we have, but to make any further progress with patients like that poor little boy, we absolutely have to go to the next level of O-CLIPS.”

“Well,” said Sam dubiously. “I suppose I could contact whoever I know in the government...”

Emily’s eyes gleamed. “Oh, Sam, could you? Don’t you see? You and

your center are going to be out of business unless you can find something else for it to do. Here at the clinic we've reached a dead end unless we can get access to unlimited O-CLIP technology. I'm proposing that we merge the two centers. With your name and connections, I *know* we won't have any trouble getting authorization for the O-CLIP we need!"

"Amen to that," said Tigernach.

Sam hung up from his call to Senator Ehrmann, puzzled for more reasons than one. This was the seventh person he had talked to from his shabby offices on the outskirts of Kansas City. At the height of its activities DEPLORE—Detection and Extermination of Painlusters and Other Representatives of Evil—had had 395,000 dues-paying members and 26 full-time staff. Even now, when he and a lone secretary were the sole remaining personnel, Sam still had easy access to thousands of government and police officials all around the world. As soon as he mentioned 3D O-CLIPs, however, all conversation stopped. The four men and women who reluctantly admitted to having heard of them declared flatly that Sam had no way in the world of ever getting his hands on an advanced O-CLIP computer.

Exasperated and mystified, Sam had called the senator who years before had led the fight for the 31st Amendment. Finally he tracked him down at his fishing camp in the Black Hills. When he mentioned O-CLIPs and why he wanted one, the old man laughed raspingly. "Remember Sena-

tor Loagmeyer and our fight for the amendment? Remember what she said about doing whatever she could to block whatever Dr. Kody's center was doing? Well, she has, my boy, in spades, may God rest her venomous soul. So well that there's nothing at all I can do to help." The senator from South Dakota paused. "At least not at the moment." He paused again. When he resumed, his voice was hushed. "Sam, this is very, very confidential, and I have never, ever said it to you. In fact we have never even had this conversation. There's a man named Wegner I want you to talk to. At least he calls himself Wegner now. I'll tell him you'll be calling—and to talk to you."

Sam heard the senator sigh heavily. "Find me a smoking gun, Sam," he said, "and I'll do what I can to help you. I've been looking for one for a long, long time now."

A smoking *gun*? Sam was baffled. What on Earth did *that* mean? Old Senator Ehrmann must be nearing eighty by now. Was he finally beginning to take leave of his senses?

"The senator says I can trust you."

"As much as anyone can be trusted."

The man who called himself Wegner nodded grimly. "I hope so. With P.E. there are no more secrets. Not if someone wants them badly enough."

"Who is the someone?"

Wegner studied Sam for a long moment, then jerked his head toward the rustic cabin half-hidden in the dark forest behind them. "Come in. We'll talk. Maybe no one will hear us."



Sam followed him into the cabin. Wegner was tall and lanky, with a hawklike nose and restless bloodshot eyes. He wore a red flannel shirt, tattered jeans, and ancient boots. His age was impossible to determine. A long gray beard brushed his chest and matted gray hair hung past his shoulders. But his face was unlined and he moved swiftly and surely. His cabin nestled high in the Yellowjack Mountains of central Idaho, twenty-six miles from the town of Challis and nearly that far from the last inhabited dwelling Sam had seen. His trash-strewn front yard was littered with the rusty remains of abandoned cars. If he wasn't a genuine mountain man, Sam said to himself, then he was certainly a fair imitation.

Wegner poured cheap bourbon

into smudged jelly jars. "Talk," he said.

Wegner had adamantly refused to talk over the phone. Sam shrugged and told him why he was there.

"Hrmph." Wegner gulped his bourbon and poured himself another. "Have you ever heard of a Project Zombie?"

"No."

"Well, you weren't supposed to. In any case, that's only what we . . . what it was nicknamed. Its real name is still the most closely guarded American secret of the last fifty years. The two of us could be thrown in jail for the rest of our lives just for mentioning it. That's one of the reasons that advanced O-CLIP technology isn't being released and never will be. There are two of them."

"Reasons?" Sam took a cautious taste of his bourbon and then another; it was amazingly smooth.

"Yes, reasons. Two of them, I said. Here's the public one, the one they managed to sell to Congress: O-CLIP technology is just too dangerous to be allowed in unlicensed hands. It works nearly as fast as the speed-of-light, you know, so that it can operate millions of times faster than a human brain, at least the massively parallel 3-dimensional ones can. Theoretically, once it's programmed correctly, a single computer could be tens of times more intelligent than any human being. Its potential danger, therefore, is enormous, almost unlimited."

"Really?" said Sam skeptically. "Why? It sounds to me just what the doctor ordered."

"Think about it for a moment," snapped Wegner, "a genuine thinking machine a hundred times smarter than Isaac Newton and Leonardo da Vinci and Albert Einstein combined—in the hands of a tinpot dictator in the Balkans with a grudge against his neighbors. Is *that* what the world needs? Congress said no. Maybe someday if we're invaded by alien monsters from Alpha Centauri they'll crank up a couple to help think us out of our jam. But until then, no, never. Applications for licenses have to go through both the Defense and Commerce Departments as well as the White House and both houses of Congress. Supposedly some will be issued someday, but you and I will never live to see it."

Sam sat back in his rickety wooden

chair and tried to order his thoughts. Whoever Wegner was—or once had been—he was certainly no ordinary mountain man. "That's one reason," he said, finally. "You also mentioned a Project Zombie."

Wegner smiled bleakly. His eyes flicked back and forth across the cabin, met Sam's briefly, and moved on. "Just for the sake of discussion—we can only be given life sentences once—let's hypothesize that we know someone who once actually worked on the project."

A chill ran through Sam. "All right," he said. "Let's."

Project Zombie, said Wegner, had been conceived and carried out in deepest secrecy by a now disbanded team of Army and civilian specialists based in a desert outpost to the south of Fort Stockton, Texas. "As you may have guessed," said Wegner, "the starting point was the same sort of research that your daughter is apparently doing at her clinic in New Mexico."

The directors of Project Zombie had a cover story to secure funding from the secret Congressional joint committee that oversaw the research. By developing this technology, they said, they would be better able to interrogate suspected spies and enemy prisoners. Even more important, they would also be able to help injured American servicemen deal with battlefield trauma.

The real research, however, focused almost entirely on implanted memories. "Suppose that by installing a complete set of false memories," Wegner demanded, "you could de-

feat an interrogation conducted under perceptualization enhancement? You could send a spy anywhere in the world with no danger of him ever betraying his origin. Or you could create the perfect assassin: capture a loyal and trusted individual, implant fake but compelling motivations, then send him out to kill the President or blow up New York City. If he got caught, the only thing he'd reveal would be the phony reason he honestly thought he had for doing the job. He could never be traced back to the real villains."

"My God," muttered Sam. "I can see why it was called Project Zombie. But why—"

"There's more. There were rumors where I... where my hypothetical friend worked, that the loyalty of a couple of people actually working on the project had come under question; the rumors said that all their memories of Project Zombie were subsequently erased and a complete set of new memories installed. My... friend managed to visit one of these people on the sly; he didn't seem to be anywhere near as smart as he had been before—and he said he suffered a lot from strange nightmares..."

Sam gulped the rest of his bourbon and held the jar out for a refill. "I can't believe this! Why hasn't anyone outside the government ever heard of this?"

Wegner shrugged. "As I said, even in Congress not everyone was aware of it. Of those that were, both the liberals and the right-wingers cooperated to keep the whole thing under wraps. Both of them were terrified of

people being outfitted with false memories—but for entirely different reasons. The right-wingers feared that the new O-CLIP technology might be used to beat P.E. interrogation of painlusters and other criminals. And that this would be done in places like your daughter's clinic."

Sam's lips tightened.

"That's the right-wingers," Wegner continued. "Over on the left, it was Senator Loagmeyer who was the main mover and shaker in trying to suppress it."

"But Loagmeyer was a liberal, a so-called civil libertarian! That's why she opposed the 31st Amendment so bitterly—it intruded on the criminals' precious right to privacy, she said."

"Well, of course. The liberals were afraid of the government using Project Zombie to reprogram criminals, starting with murderers and painlusters, then maybe working down to child abusers, then thieves, then security risks who talk out of turn, then the mentally ill, and then finally maybe just anyone at all foolish enough to oppose the government. In other words, reprogram any and all non-conformists to government-defined standards."

"But why didn't they go *public* with this?" demanded Sam. "That's the way to stop something like this!"

"Maybe," Wegner shrugged, "maybe not. Think how many people are out there right now who are just dying to readjust you and me in any number of ways to meet their own infallible standards: me because I don't believe in six-day Creation, maybe, you because you don't be-

lieve the Earth is flat."

"But—"

"And maybe they hushed it up because the congressmen thought that if they tried to go public with it, just maybe, *they* might get themselves readjusted before they had a chance to. . . ."

Sam shook his head in dismayed disbelief.

"In any case, all research has now been halted in the United States and the whole thing declared off limits and top secret." Wegner smiled bitterly. "My friend thought they might try to tidy up loose ends by readjusting everyone who had worked on the project. That's why he . . . more or less disappeared from sight."

"And that's why Emily will never get her O-CLIP computer."

Wegner swung easily to his feet. "That's why." He walked Sam to the cabin's ramshackle porch. "One other thing might interest you. As I said, Project Zombie was formally disbanded. Parts of it, however, were surreptitiously farmed out to a research unit run by Brazilian security forces for further work—which might, of course, someday be shared with interested parties here in the States."

Once again a chill ran through Sam. "So research is still being done?"

"In a place called Villa Mimosa just outside the Brazilian town of Belo Horizonte, about 200 miles north of Rio."

"Belo Horizonte?"

"Yes. Beautiful Horizon in Portuguese. Appropriate, wouldn't you say?"

Once again Sam could only shake his head. Just before he stepped down from the porch a final thought occurred to him. "Senator Ehrmann mentioned something about a smoking gun. Do you know what he means by that?"

"Smoking gun? So the senator has set the great painluster hunter on the trail of a smoking gun, has he? Well, well, well, that's very interesting." Wegner's restless eyes met Sam's. "You don't remember your Watergate?"

"Watergate? You mean that old political scandal?"

"Yes. It popularized the term *smoking gun*, at least for a while. It means indisputable evidence or proof—especially of a crime."

"I thought about it on the way back," said Sam to Emily the next day over dinner, "and in spite of all the awful uses to which it could be put, I still don't see why this . . . this treatment couldn't be used on all the murderers and criminals who are now being executed." He turned his gaze to Tigernach, who was stolidly eating roast beef. "Your ten teenaged feel-me snatchers could be put back on the streets as model citizens instead of . . . well, being dead."

"Sounds good as an idea, all right," grunted Tigernach, "but then so did P.E. when people like you were exclaiming about its virtues to Congressional committees." He stuffed another piece of meat into his mouth and washed it down with ale. "Who'd have thought it would lead to 10,000 executions a year?"

Sam looked at Tigernach and then his daughter in bewilderment. "But your whole life is devoted to banning the death penalty and curing people! Here's the means of doing both! Why don't you—"

Emily laid a gentle hand on Sam's wrist. "Daddy: who would do the readjusting, and who would define the standards—and pick the criminals? Who—"

"—Would guard the guardians?" demanded Tigernach. "That's the—"

"Emily! Sam!" Dr. Kody's bird-like face suddenly leaned over the table. "It's Marianna! She... she's been rounded up in Brazil in a painluster sweep!" Her fingers tightened on Sam's shoulders like talons. "Sam, you've got to save her, you know what they do to painlusters in Brazil, you've just got to save her!"

Sam looked at her in bewilderment. "Marianna? That nurse I saw in the little boy's room? That shy little girl a painluster?"

Emily had jumped to her feet and was impatiently tugging at Sam's arm. "Oh, Sam, of course she isn't a painluster!"

"But what's she doing in Brazil?" asked Sam plaintively as they hurried through the clinic to Dr. Kody's office.

"That's where she's from," said Emily over her shoulder. "She was born there. She went back on vacation, she said she hadn't been there in almost twenty years. We—"

"We what?" demanded Sam.

"We warned her not to go. Not because we thought anything like *this* would happen, but because we didn't

think she was emotionally ready for it."

"Emotionally ready for it?" Sam perched on the edge of Dr. Kody's couch. "What does that mean?"

To Sam's dismay Emily burst into tears. "Oh, Sam," she choked out between anguished sobs, "remember that little Brazilian girl you saw beneath the dead birds in Hawaii, the one whose parents had brought her to watch. That's Marianna..."

Sam fell back in shock. That small, wide-eyed child had haunted his dreams for twenty years. How could she possibly be—

"Emily! What's going on here?"

Emily shook her head and haltingly told her story.

Emily and Dr. Kody had known of Marianna's identity ever since the Brazilian girl arrived at the clinic three years earlier as a troubled young woman. No one from Brazil had come forward to claim her after her parents had been killed in Hawaii, so eventually she had been raised as a ward of a family in Oregon and had become an American citizen. She had, said Emily, been severely traumatized by the terrible events of her past and had had an emotionally troubled childhood and youth. Eventually she had heard of the clinic and had come to it for sympathy and help. She had been undergoing therapy ever since, paying for it by working with the children and training to become a nurse. Emily hadn't revealed her identity to Sam for fear of a possibly irrational reaction.

Sam felt his soul shrivel at her words. "Are you telling me that you

think I'm *crazy*? That I might have tried to *hurt* her?"

"Poor Sam," said Emily, throwing her arms around him and hugging him tightly. "Poor, poor Sam. Let's just say that you . . . suffered terribly in Hawaii, and that you still have all your memories of those events. And over the years, you know, you've shown moments of what some people might call . . . obsession."

Sam looked over Emily's shoulder at the hands that were wrapped across her back. Hands that were covered with blood? Was that what even his own daughter saw on them?

Maybe he *had* spent too long helping to kill people—even if they were monsters.

Maybe now it was finally time to try to save them.

"But, Major Sousa de Macedo, I give you my solemn word that this girl could not possibly be a painluster."

"And I do believe you, my dear Senhor Ferron, how could I not after all the years I have known you? But my opinion, unfortunately, counts for nothing in this affair. Her name was flagged by the central records computer as soon as she entered the country. After that her detention was automatic."

"Because her parents were painlusters when she was six years old?"

"Such is the case, I fear. Our new administration has vowed to stamp out every last remnant of the paincults in Brazil. And, of course, it is clearly on the record, partly as a result of information from your own

center, that she was present at certain painluster rites in Hawaii. And there is irrefutable evidence that her parents were most definitely the leaders of a major paincult here in this country."

"When she was six years old," repeated Sam bitterly. He forced himself to take a deep breath. "All right, all that's something for the lawyers to argue over—once we've found her. You say you don't even know where she is?"

"I am desolated, Senhor Ferron, believe me, but as I said, the matter is completely out of my hands. By the time I located the unit that had made the actual arrest of Senhorita Pereira Brand, she had already been moved from the detention center in São Paulo. I am completely unable to trace her movements after that."

"But she can't just *vanish*, Major Sousa de Macedo! She's got to be somewhere!"

"Let us devoutly hope so, Senhor Ferron." The voice on the phone dropped to little more than a whisper. "It was the Fourth Financial Security Division who removed her from the center. I fear that they answer to no one at all. Even their existence is . . . highly unofficial."

An icy hand tightened around Sam's heart. "One of the death squads?" he whispered.

"We have no DEA—none of those in Brazil, Senhor Ferron."

"No, of course not. Forgive me. So there's absolutely *nothing* you can tell me about where she might be? I swear to you, completely off the record."

"Hmmm." The Brazilian's voice grew even softer. "As an old friend and colleague of yours, Senhor Ferron, I can only say that you must look in every direction, that you must look beyond the horizon, beyond even that *beautiful* horizon. Do you follow me?"

Sam was silent for a long moment. "Do you know, Major Sousa de Macedo, I believe I do. Thank you so much."

The engines of the forty-year-old Atlas Worldlifter droned through the night sixty-five miles west of the Colombian coast. The Pacific Ocean was 47,000 feet below and the Panama Canal not far behind; in a few minutes they would cross the coastline and start moving into the interior of South America. The Worldlifter was holding a steady 640 miles per hour. Unless the ancient VTOL fell out of the skies from sheer exhaustion, four more hours would see them across the sparsely inhabited rain forests of Columbia and Brazil to their goal midway between Belo Horizonte and Sete Lagoas.

Sam had found the battered but still serviceable freighter sitting in a hangar just west of San Antonio. DEPLORE had chartered it through the name of a now-defunct storefront legal firm that had once been part of a sting operation against a paincult in Columbus, Ohio. A three-hour stop in a secluded valley near the Pedernales River had allowed Tigernach and his twenty rowdies to camouflage it with a computerized pattern of multi-colored radar-deflecting paints. A man

who had lost his only son to painlusters sat at the controls.

"I still can't believe they'll be prepared for a frontal attack," muttered Sam, squirming nervously on his hard seat in the stark cargo hold. He bent down to rub his throbbing ankle. "Or expecting any kind of an attack at all. I mean, who'd bloody well dare?"

"That's what I keep telling meself," said Tigernach. "The desire to finish me days at the hands of a brain-scrubbing Brazilian death squad is infinitely less than nil. Why, oh why did I ever let a pretty face divert me from my chosen path? Let me see those pictures again."

Peekaboo Satellite Services had delivered—for a substantial fee—267 computer-enhanced pictures of what appeared to be an ordinary farming complex about thirty-five miles northwest of Belo Horizonte. By the time PSS had pulled the pictures from its files, Tigernach had gathered a group of brawny idealists from all over the country. One of them was a Sandhurst graduate who had gone on to become—before his dishonorable discharge—a captain of Israeli Army Intelligence.

"So this is Villa Mimosa," murmured ex-Captain Horowitz, scrutinizing the pictures in the conference room of the Hallowell Trauma Center. "Right, then. We're lucky: lots of shots, both daytime and night. Except for this one little guard post here on the main road about a mile away from the villa, there only seem to be two guards outside the buildings at any time. We'll figure two or three guards at the most in the guard post. No

heavy armaments or other defensive measures—at least that I can see. No dogs, thank God. I hate dogs: one of them got me by the neck once and had a bloody fine meal. We've got a barn, a garage, what looks like a dairy, and the main house. Hmmm, another lucky break: everything except the barn's only one story high."

"Why's that lucky?" asked Sam.

"Ever tried to run up a flight of stairs defended by a chappie with a machine gun at the top? No? Then don't." Horowitz tapped the pictures. "It's a genuine farm, in other words, that's been turned into a research center on the cheap."

"You're *sure* it has been, though? We don't want to go busting in on a bunch of innocent dairy farmers."

"Innocent dairy farmers don't have power lines like this. Or concertina wire here, here, here and *here*. Not to mention armed guards here, here, and here." Horowitz, a small, dapper black man with a shiny skull, a neat moustache and goatee, and a tiny silver dagger hanging from his left earlobe, grinned broadly as his finger stabbed at the pictures. "Not unless they have some awfully valuable cows to protect."

"But how do we know she's even there?" demanded Tigernach. He was scowling at the large-scale holographic map of south-central Brazil that Dr. Kody's office library had printed for them two days earlier.

"We *don't* know that she's there," snapped Sam irritably. "But three days of twisting arms in Washington and Brazil hasn't gotten me anywhere. I admit we're down to grasp-

ing at straws, but it's the only straw in town. Just be thankful that Wegner actually visited this hell-hole and could give us the precise location." Sam looked at Tigernach grimly. "Wegner also said, just before he hung up, 'Better for her that she should be killed outright than be at Belo Horizonte.'"

"Not so," said Horowitz with a faint sigh. "I think they can have it both ways." He pointed at one of the pictures. "See how the grass pattern is different in all these spots? I would be greatly surprised if those weren't graves."

There were at least a hundred of them.

Tigernach took a deep breath and looked around the table. "All right then, me boyos, so we'll go and fetch the lass."

"Ahhh now," said Captain Horowitz softly, "*fetch* her. That's *precisely* the word I was looking for. A quick in and out and we're away. It's that or nothing."

"What do you mean?" asked Sam.

"I know how rough and tough our little band of Tiger's street fighters likes to think it is, but that's all it is: street fighters armed with tear gas, rubber truncheons, baseball bats, and riot control prods. Except for me, we're not trained soldiers. If we come up against any who are, we'll all be dead. So far we'll have surprise on our side and nothing else. We need an edge, a real one. Sam, that ultra-low frequency sound projector you've been talking about will probably be useful in taking out the guards at the main road and around the buildings,

but that's about all."

"But I saw it used on a paincult raid," Sam protested. "It worked perfectly: the painlusters were flopping around on the floor like fish out of water. They didn't know *where* they were."

"We'll use it against the guards if we can. But in buildings with lots of rooms and all sorts of different acoustical properties it'll be almost useless. Every material is different; sometimes the sonic frequencies go through them, sometimes they don't. Also, it's easy to take defensive measures against infrasonics even if someone is pointing a projector directly at your head. That's why the army has never really used it. And why you've got a left-over one no one cares you've got." Horowitz's eyes moved from Sam to Tigernach and he set his mouth firmly. "We get an edge or we don't go."

"You know," said Sam into the long silence, "let me talk to Dr. Kody. I think I may have an idea. . . ."

At 2:36 the Moon slipped beneath the horizon and the night grew even darker. Ten minutes later the Worldlifter lumbered through the sky three miles west of Villa Mimosa, its altitude less than 3,000 feet. The sound of its engines gradually changed pitch as it slowed to a near-hover. Jouncing and shuddering, engines wailing, it suddenly dropped like a stone. Sam's eyes were shut, his hands clenched around the edges of his metal seat. An enormous bounce and the plane was down.

Sam opened his eyes. They had

landed; he was still alive.

The rear cargo doors opened and the ramp descended. A black motorcycle slid down the ramp and disappeared into the night. The driver, dressed entirely in black, wore military nightvu goggles; the cycle was an Army reconnaissance model that emitted little more than a throaty whisper.

The ensuing wait seemed endless to Sam but was actually no more than seven minutes. Suddenly a voice spoke into his earplug.

"No problems at all, no traffic on either road. I went past the guardhouse at about 30 miles an hour. It was dark, no lights anywhere. No one standing outside. Looked like a truck parked behind. Everything was as quiet as the grave."

"Thanks for the cheerful imagery, laddie," said Horowitz's voice in the earplug. "Right then, stay where you are till I tell you to join us." Horowitz turned to the men waiting in the darkness. "All right, gentlemen, here's your chance to be heroes. Everyone's got his gear? All of your earplugs are working? Remember: all of you have throat mikes, but there's absolutely no talking by anyone except me unless it's absolutely vital. Got that? Then let's go."

Sam was in the sidecar of Horowitz's motorcycle, the sound projector in his lap. His pants, gloves, and sweater were black; so was the skier's hood that covered his head. The motorcycle bounded a hundred yards across the pasture, then swung abruptly onto a dirt road and turned right. "Bloody cinema stars we are," muttered Horowitz as they sped down the rutted track. Sam grinned half-heartedly and

readjusted his nightvu goggles. The rider in the sidecar that preceded them through the darkness had a high speed Canon RecordAll trained on them; so did the man in the sidecar immediately behind them. Tigernach had insisted on recording every moment of the expedition.

"Right, then," said Horowitz when the track ended at a two-lane paved road, "the rest of you stay here until we take care of the guardhouse." Still flanked by Tigernach's cameramen, the motorcycle and its sidecar moved off into the night.

To Sam's right was a barely visible fence of what the satellite photographs said was razor-sharp concertina wire. It blurred past, then began to grow slightly more distinct as Horowitz cut the engine and let the motorcycle drift silently forward. "There's the guardhouse. Are you ready?"

"I'm ready," said Sam. He and Horowitz pulled infrasonic dampeners over their heads, thick blue watch caps made up of thousands of gas-filled silicon-propylene bubbles that were, Horowitz assured him, impervious to the frequencies of the projector Sam was about to use.

"Now!"

Sam felt a deep vibration resonating through his body as he pointed the projector at the looming blackness of the guardhouse. The motorcycle slowed to a stop; eventually Horowitz's fingers tapped Sam's shoulder. Sam released the trigger and pulled off his dampener cap. Horowitz was already at the chainlink gate, slicing through it with a glowing laser torch. Ten seconds later he had vanished

into the guardhouse.

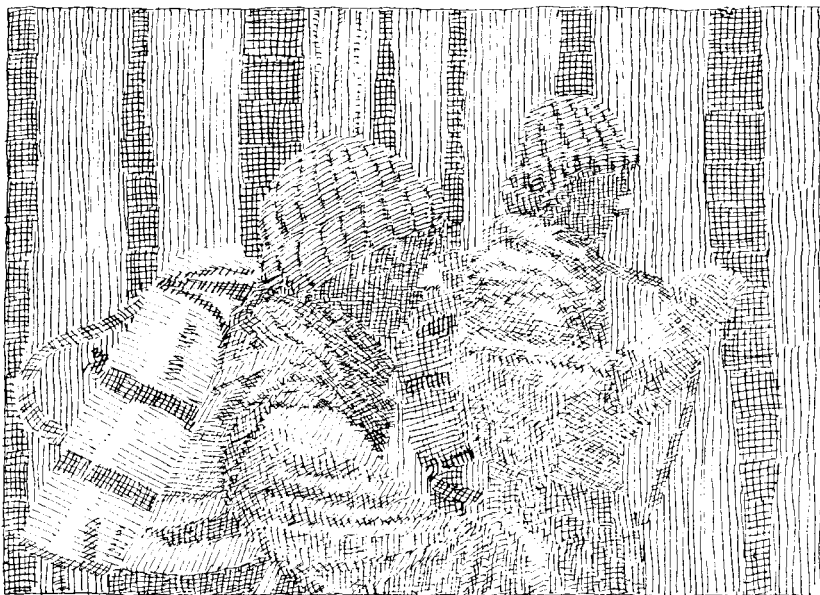
"All taken care of," came Horowitz's voice just as Sam was becoming anxious, "your projector worked just fine. There's two of them here, all wrapped up now like bugs in a rug." He emerged and used the torch to cut away the gate's padlock. "The others are on their way. Now let's get all these cycles off the road and out of sight. We've got a fine looking lorry here: let's use it."

Five minutes later they were joined by the other eight motorcycles and their two-man cars. Tigernach nodded in satisfaction at the sight of his two cameramen moving purposefully about with their recorders on their shoulders.

"Right then, all of you sidemen into that lorry along with all of your gear," ordered Horowitz. "The rest of you wait here till I call."

The truck rolled down the narrow road toward the Villa Mimosa.

No one seemed to notice their approach. Horowitz pulled the truck off the road and into a dark copse of trees just before the buildings came into view. He jumped to the ground with a pair of binoculars and vanished into the darkness. Five minutes later he returned, murmuring into his throat mike. "One of the guards is asleep in a chair on the front porch. The other one I couldn't locate, so I assume he's out back somewhere. The only lights are in the dairy. There's a helicopter and half a dozen cars. You, you and you: when the time comes, your job is to immobilize them." Sam could see Horowitz shaking his head against the starry sky. "I wish we weren't so



bloody concerned about not leaving corpses behind; it'd be a cinch to pick off that feller on the porch. Ah well, we'll just have to do it the hard way. Dick, you and Gerald are the lightfoot lads here. You have your truncheons? Right then, lads, off we go, softly, softly. The two of you will converge on the chappie on the porch and I'll find the other one wherever he may be . . ."

Ten minutes passed in ever mounting tension. At last three black forms slipped into the trees. "Righto," said Horowitz with grim satisfaction, "the grounds have been secured. There seems to be a couple of Charlies hard at it in the dairy, but everyone else is off in the land of nod. Let's get the other lads up from the road and map out the next step."

Nine oxygen tanks had been deliv-

ered to Sam by a scuba equipment store in Albuquerque. Long black hoses with a broad selection of nozzles had been attached to the tanks. Now they were unloaded from the truck and distributed among nine pairs of men. One man attached a tank to his back; his partner took the hose. From their belts dangled a truncheon, a riot control prod, and a tear gas dispenser. "At least you all *look* bloody dangerous," muttered Horowitz. "—if you can keep from tripping over yourselves. All of you have your respirators? Right, then, lads, off we go. And if any of you bloody cameramen get in our way, I'll have your livers on toast." The teams moved away from the truck and through the trees. Sam carried nothing but his sound projector and a truncheon as he kept pace with Horowitz.

witz. The former Captain of Intelligence resembled a walking arsenal; Sam rather doubted if all his hardware was certifiably non-lethal. . . .

They moved out of the trees, across a lawn, and onto a broad concrete courtyard, Horowitz whispering a constant stream of instructions into his throat mike as they went. The farm's buildings loomed against the sky, nearly as clear through Sam's nightvu goggles as if it had been daylight. A small helicopter sat in the middle of the courtyard. "Right then, Sam," murmured Horowitz's voice in his earplug, "you and I will just take a peek into the dairy. That's where Wegner said all the interesting stuff was going on." They turned and ghosted past the side of the barn. Two teams of men were already pushing slim nozzles beneath the barn's loosely fitting doors. Sam saw that their hooded faces now sprouted the grotesque snouts of chemical warfare respirators. A few yards away to Sam's right a cameraman danced agilely backwards, his recorder pressed to his face.

"Mask on?"

Sam pulled the respirator up from his chest and snapped it over his face and goggles. "It's on."

"Let's go. Softly, softly, catchee monkey."

The two lighted windows in the dairy were about halfway along the long, low buildings. One of Tigernach's teams knelt by a narrow side door, pumping neobenzodiazepine-based CNS inhibitor into the building. Farther down the building, past the lighted windows, another team crouched beside a second door. Sam

could see still others at work at the garage and main farmhouse.

Sam and Horowitz crouched beneath the second of the lighted windows. Both windows were covered with heavy steel mesh. Five minutes dragged slowly by. Sam's thighs were beginning to cramp when Horowitz raised his head cautiously to steal a glance through the window. "Damn! They're still awake! Their room must be tightly sealed and the gas isn't getting through. We'll have to go in and get them from inside."

They moved back to the side door. The two men who had been pumping inhibitor were standing by the door gripping their truncheons. "Are we going in with you?" whispered one.

"Wait till I check with the others." Horowitz listened to brief reports from the other teams. "All right, everything's going smoothly with them, they've covered every door they've found and they're about ready to start moving inside. You chaps—Dabney? Mackey?—come with us. First we'll get that room with the lights, then you start pumping it under every other door you see."

The side door opened into a small bare room with a single desk. They moved through it and into a dimly lighted hallway. As Sam readjusted the settings of his nightvu goggles, he saw that Horowitz was now cradling a small riot-control gun. "Rubber bullets, laddie, rubber bullets. Wouldn't want to kill any of the little darlin's, would we?"

Just ahead, the body of a man lay across the hallway. Sam could hear him breathing stertorously. Horowitz

jerked the Brazilian's wristphone away, then produced a thick roll of tape and swiftly bound his hands, legs and mouth. They pushed him aside and moved on.

"This should be the one." Horowitz scowled at a heavy metal door with overlapping flanges around the edges. "Damn! There's absolutely no place to slip a nozzle through. Right, then." He turned to the team with the tank of inhibitor. "Get it ready to start spraying. If the sound doesn't work, give them a blast. And if that doesn't work, I'll shoot 'em. Sam, are you ready with that gadget of yours?"

Sam nodded as he fumbled to pull the dampening cap over his head. He raised the infrasonic projector.

"Everyone has their caps in place? Then go!" Horowitz jerked open the door. Sam stepped into the doorway and held his finger to the trigger of the projector. Two men and a woman stood looking at him with astonished eyes, then began to jerk like spasmodic puppets. One of them staggered backwards against the wall, then crashed to the floor. The two others lay twitching across what seemed to be a dentist's chair.

"Enough," said Horowitz. He stepped past Sam and manhandled the two Brazilians to the floor, then bound and gagged all three of them. He turned to Dabney and Mackey. "Take care of the rest of the building. Be careful."

Sam closed the door behind them and turned back to the dentist's chair. A man was strapped to it. He was naked except for a pair of filthy shorts; he hadn't shaved in weeks. His body was covered with bruises and festering

sores. A shiny metal helmet similar to what Sam had seen at the Hallowell Trauma Center covered most of his head.

"Bloody hell!" muttered Horowitz, pulling a needle from the man's arm. "They really *are* playing at dirty buggers!"

"Dirty buggers? What the hell are you talk—"

The words paralyzed Sam for a moment, then he swung around to see an enormous man in a pale blue uniform standing in a doorway that had opened just behind Horowitz. The man seemed to be fully as astonished as Sam. "Wha—"

Horowitz was already leaping with his truncheon raised. The giant ducked with astonishing agility and lashed out with a massive foot, catching Horowitz heavily in the stomach. As Sam stood gaping, another man pushed through the doorway and jumped at him with outstretched arms. Instinctively Sam threw the projector into the attacker's face and twisted away from the hands. Somehow he remembered his truncheon. His hands fumbled with it, and then he swung it like a baseball bat. A sharp cry of pain and a heavy form tumbled to the floor.

Sam looked up to see Horowitz pinned to the wall by the giant in blue, the Captain's head being pounded against a multi-dialed instrument panel. Sam stepped forward and with all his might smashed the truncheon across the small of the giant's back. His back arched and his hands jerked away from Horowitz's neck. Sam hit him on the side of the head, and then a second time. He collapsed slowly to the floor.

"Who the bloody hell was *that*?" demanded Horowitz, shaking his head groggily. "And why the hell was he speaking English? Mackey, Dabney, get back here quick!" Horowitz slammed the door shut. "Sam, tape up those two characters on the floor. Be sure and get their wristphones. Give them lots of tape—and another belt with the billy if you think they're shamming." He took a deep breath. "Oh—and thanks."

Sam had finished binding the giant and was beginning on the other man when Mackey and Dabney burst into the room. Horowitz pointed at the door. "I'll pull it open just a bit, you pump in everything you've got left."

"Right." Mackey and Dabney arranged their equipment by the door. Horowitz eased the thick, sound-proofed door open a crack. A clamor of voices filled the room. "Wait!" said Dabney, cocking his head. "Some of them are speaking English—and they're calling for help."

Even with his respirator in place, Sam knew that the cellar stank. Twenty-five or thirty prisoners of both sexes were jammed into a single makeshift cell that might comfortably have held a dozen. Most of them were shackled to the roughly dressed granite walls. The rest lay comatose in the filthy straw that covered the floor.

Marianna was one of those who were shackled to the wall. Her vacant eyes stared calmly at nothing. She wore nothing but a tattered blanket across one shoulder. Sam's thoughts leaped to the improvised cell in which he had been chained by painlusters twenty years before, and he was suddenly

gripped by as black a rage as he had ever known. He raised his truncheon with a violently shaking hand. First he'd kill those monsters lying bound on the floor above, and then he'd—

"Easy, Sam, easy," Horowitz laid a firm hand on his arm. "It's not our country, you know."

Sam shook his head like a dog shedding water. "How . . . how do we get them off?" he said finally between clenched teeth.

"Mackey's looking for the keys upstairs. If he can't find them, we'll have to use the laser torch."

Marianna was the first one to be released. She was able to walk in a stumbling, dreamlike fashion. Sam led her slowly up the stairs. She stood docilely in the center of the room, ignoring the men on the floor. Sam found a glossy camel's hair coat in a closet and substituted that for the blanket. He led her to a chair and gently pushed her into it.

His eyes fell on the giant wearing the pale blue uniform. He had spoken what sounded like standard American English. . . .

"Tiger," he called down the stairs. "Send a cameraman up here. He might like to record whatever I find in this guy's pockets. . . ."

"A Major in the Special Services," said Tigernach with relish as he leafed through the contents of the giant's wallet. "Beautiful, beautiful, proof absolute." He tapped the toe of his steel-shod boot against the Major's temple with no great gentleness. "You're going to be a video star, me boyo, that I can absolutely guarantee you."

Horowitz came up the stairs, shaking his head in disgust. "The lads have

been through the rest of the buildings, there's nothing of any interest except soundly sleeping Brazilians. What's that you're doing?"

"Loading up all the computers and files we can carry," said Sam. "We want to be able to document all this. There're plenty of cars out there to carry it to the plane."

"Ah." Horowitz rubbed his chin through the ski hood that covered his face. "You *are* an incorrigible do-gooder, aren't you? And I suppose—?"

"All of those other poor people?" murmured Sam. "Yes."

Horowitz sighed. "There's room."

"That's what I thought. Let's start bringing some of the cars around. We'll take them with us."

The false dawn had brightened the horizon briefly and then faded again to inky darkness by the time they drove the truck up the ramp into the Worldlifter's capacious innards. The freighter's pilot turned away from the empty drums from which he had just finished refueling the plane. "We've got twenty minutes of darkness left," he said. "We can take off with that truck and all these cars aboard but it'll cut down drastically on our range."

"We'll be leaving them here," said Horowitz, "just as soon as we get the last of these people out."

"And then what?" said Tigernach without looking up from his position behind one of the cameramen.

"Just as we planned," said Sam. "Two hundred and seventy miles due east to get us out over the Atlantic as soon as possible, then we head north, looping around the Brazilian coastline by at least three hundred miles. We ought to be in

Jacksonville by early afternoon."

"No, no, I meant all these people here. What about them?"

"We're scofflaws, remember? We'll smuggle them into the States. Mari-anna and the others will go to the clinic." Sam looked down at the still unconscious form of Major Mendoza of Special Services. "And after we've dropped *them* off, I think we can make a little bit of a detour before we return the plane. . . ."

"I asked you to find a smoking gun, Sam; I didn't ask you to *bring* it to me, especially not in the form of a Special Services Major."

"I didn't know what else to do with him, Senator. It was either that or throw him out of the airplane at 40,000 feet."

"I don't suppose you simply considered leaving him behind."

"No, Senator, I didn't."

The old man scowled at Sam from behind his ornate Victorian desk, then sighed faintly. "Well, hoisted by my own petard, I suppose. What did you think I was going to do with a hog-tied United States military officer on the front porch of my fishing shack at three o'clock in the morning? I mean, in order to keep from joining one Samuel G. Ferron in a federal prison on a capital charge of kidnapping?"

"I didn't really know, sir, I just counted on your abilities." Sam glanced out the sixth-story window of the senator's Rapid City office at the morning sunlight on the distant peaks of the Black Hills, and grinned faintly. "But you seem to have done it: neither of us are in prison."

"That remains to be seen." The senator leaned forward to sip carefully at his cup of coffee. "Tell me again precisely what you and this mad Irishman of yours did with the copies you made of your recording?"

"It was a long flight home. If you're a professional agitator like Tiger you're prepared for everything. He had all sorts of duplicating equipment aboard. By the time we reached Jacksonville he'd edited the original recording, added the narration, and made 128 copies. As soon as we landed we mailed copies to the Joint Chiefs of Staff, members of the Cabinet, every senator and representative I know personally, and all the Supreme Court justices. The remaining twenty or thirty went to various people scattered around the world—just for safekeeping, shall we say."

"To be given to the media if something happens to you? Sound thinking, Sam—for a blackmailer."

Sam's eyebrows shot up. "You're calling me a blackmailer?"

"Aren't you?"

"I prefer to think that I'm playing politics the way it's always been played."

The old man scratched his chin. "There is that. And you and this Tiger of yours now threaten to go public with everything you know unless Congressional and executive action is taken so that—" he began to enumerate items on his fingers "—One, full capacity, 3D O-CLIPs will no longer be used by the government in any capacity, particularly the military. Two, full capacity 3D O-CLIPs will not be used in any way in the so-

called treatment of criminals. Three, full capacity 3D O-CLIP computers will be licensed to a limited number of accredited medical centers under the strict supervision of an independent agency to be established by Congress. Four, your daughter's clinic will be one of those receiving a license. And five, I—the senior senator from South Dakota—will publicly and forcefully come out in favor of abolishing the death penalty. Is there anything I've left out, Sam? Some minor thing like crowning you king of the United States maybe?"

Sam grinned. "I'll pass on that, thanks."

"And what in return do I—we—get from you?"

"Well, for the others, complete silence about any U.S. military complicity in what was going on in Brazil. For you, Senator, the smoking gun you asked for. I assume that you wanted it in order to carry out at least part of the agenda you just ticked off. I can't imagine that you were ever very happy about letting the executive branch and the military bottle up this stuff for themselves. That's two things I've got to offer. The other thing you get—" Sam shrugged "—or the liberal agenda gets, is, for what it's worth, my own full support for the abolition of the death penalty. Times have changed, Senator, I think it's time for DEPLORE to move on to something else. There's been enough killing in this country. Healing the scars of the Great Sweep will be a good place to start."

Senator Ehrmann's eyes met Sam's and held them. "All right, Sam,"

he said at last. "I'll see what I can do."

Six months later Sam sat at a candle-lit table in a darkened corner of the clinic's dining room.

"A last little drop of wine?"

Marianna's great brown eyes flicked from Sam to Emily questioningly.

"No reason why you shouldn't," said Emily. "But just a drop and then it's off to bed for you."

Marianna nodded, her face beaming. "Yes, please, Sam. I would like that very much." She sipped her wine with obvious pleasure, then rose gracefully to her feet. Sam hastened to pull her chair away.

"Good night, Marianna. I'm pleased to see you looking so well. And so beautiful."

The girl flushed. "Thank . . . thank you, Sam. I . . . I—" She leaned forward to brush her lips against Sam's cheek, then quickly fled the candle-lit dining room, her long black hair swinging against her slender back.

"Hrmph, she certainly isn't as shy as she used to be," said Sam, looking a little flustered, when he had regained his seat. He rubbed a finger pensively against his cheek where she had kissed him. "I guess you could call that progress."

"I don't think she's . . . afraid of you anymore."

Sam tried to hide his sudden em-

barrassment. "You're using the new O-CLIP in her treatment?"

"Yes, it really does make all the difference, just as we hoped it would. Whatever the ethics of it, we simply snipped out everything that happened from the day before she left for Brazil to when you brought her back. We told her she'd been in an automobile accident and suffered a partial amnesia. For the last month we've been tracking down and erasing all the false memories the Brazilians tried to insert. Fortunately they didn't have enough time to do much damage—we think. Some of the other poor people you brought in are much, much worse off."

Sam nodded somberly. "But Marianna, someday she'll be . . . normal?"

Emily looked at him soberly, then broke into a faint smile. "Yes, I think so. Completely normal. Why, dear father? What could you possibly have in—excuse me, I've got a call." She held her wristphone to her ear, listened, then turned to Sam.

"It's Tigernach," she said jubilantly. "The 32nd Amendment has just been ratified by the House."

Capital punishment is hereby declared to be cruel and unusual punishment and is forbidden throughout the United States, its possessions and territories.

—The 32nd Amendment, ratified by Congress 14 July 2057, in force 1 January 2059. ■

(EDITOR'S NOTE: This story is a sequel to "Under the Wings of Owls," in our January 1994 issue.)

THE REFERENCE LIBRARY Tom Easton

Foreigner, Robert J. Sawyer, Ace, \$4.99, 248 pp.

(ISBN: 0-441-00017-7).

Godspeed, Charles Sheffield, TOR, \$21.95, 352 pp.

(ISBN:0-312-85317-3).

Brother Termite, Patricia Anthony, Harcourt Brace, \$21.95, 226 pp.

(ISBN:0-15-114422-2).

Healer, Kris Jensen, DAW, \$4.99, 332 pp. (ISBN:0-88677-570-1).

Into the Green, Charles de Lint, TOR, \$19.95, 253 pp.

(ISBN:0-312-08087-5).

Satellite Night Special, Jack Hopkins, Ace, \$4.99, 236 pp.

(ISBN:0-441-75047-8).

The Well-Favored Man, Elizabeth Willey, TOR, \$22.95, 441 pp.

(ISBN:0-312-85590-7).

The Dream Machines, Ron Miller, Krieger Publishing Co. (P. O. Box 9542, Melbourne, FL 32902-9542), \$112.50, 714 + xiv pp.

(ISBN:0-89464-039-9).

With **Foreigner**, Robert J. Sawyer concludes his Quintaglio Trilogy—in which sentient dinosaurs transplanted to the moon of a gas giant far away from Earth develop a civilization and culture deeply marked by intense territoriality. In the first volume, *Far-Seer*, A Galileo-Newton-Roche figure, Afsan, used a telescope to make a number of discoveries about this world's heavens and comes to a shattering insight about the destiny of his world: it was doomed to fragment into a ring like those he could see around other worlds; the Quintaglio species must flee its world or die. Unfortunately,

Quintaglio technology was nowhere near up to the task, and the tale ended with little more than a sense of desperate purpose. Punished for his heresies, Afsan was blinded. Rewarded for his insights, his children were spared the harrowing of the blood-priests that normally slaughtered seven out of every clutch of eight egg-lings.

Fossil Hunter gave us Afsan's son, Toroca, strangely nonterritorial, studying fossils, gaining insights into evolution and natural selection, a Darwin figure baffled by the obvious evidence that life appeared on the Quintaglio world all at once. The discovery of a crashed spaceship re-

vealed how life had arrived. Just as has happened on Earth, intelligent life lost any sense it might have had of being the center of the Universe.

On Earth, of course, anthropocentricity took another blow from Sigmund Freud, and Sawyer has not forgotten that. As *Foreigner* begins, Afsan suffers a terrible injury. When he heals, his eyes finally regenerate. Yet he cannot see, and the emperor himself, old friend, urges him to see a new healer whose "talking cure" offers hope for "hysterical" incapacities. Meanwhile, Toroca is on a voyage of exploration on the other side of the world, discovering a different race of Quintaglio-like beings who are nonterritorial and have a superior technology (e.g., firearms); unfortunately, they rouse normally territorial Quintaglios to frenzied rage. The first encounter ends in murder. Only Toroca can sit face to face with the Others to learn their language.

Meanwhile also, Afsan's mate and Toroca's mother, Novato, is studying the alien starship when she activates an emergency mechanism. Nanotechnological beasts transform the rock around the ship into the same blue harder-than-diamond material that makes up the ship, and build first a pyramid and then a ladder reaching through the clouds to. . . . No one knows where it goes, so when elevator cars begin sliding up and down its length, taking twenty days for a round trip, Novato goes for a ride.

The various elements of the tale have to come together in such a way as to end the trilogy satisfactorily, and of course they do. But the most inter-

esting aspect of the book may be what Sawyer has done with his Freud-analog, Nav-Mokleb (check out the acknowledgements page to see where Sawyer got this name). Sex and toilet-training are not earth-shattering issues for the Quintaglios. But territoriality is, and every living Quintaglio has undergone a primal trauma to top anything the Freudians and their successors ever came up with. Sawyer deserves a round of vigorous applause for what he has done with this idea.

On the other hand, we can balance out the praise just a little by giggling him for a Jack and the Beanstalk reference that necessarily jars in a society of nonagricultural carnivores. But I'm quibbling. The book's pluses vastly overpower any weaknesses it may have, even the admittedly hasty jump to the finale.

And there *is* room for a sequel.

Charles Sheffield's **Godspeed** has a lot in common with the old Heinlein juveniles, and it will surely appeal to the same audience. Teen Jay Hara lives with his mother and Uncle Duncan in a small house beside a lake on the world of Maveen. From time to time, spacers visit and Mama shoos Jay and Duncan out of the way. She is clearly a sort of spaceport whore, even though the spaceport is on the other side of the lake. Later we learn that women are of special value on Maveen because they are scarce. This world has been isolated for centuries from the rest of humanity, and it does not supply humans with all the nutrients they need to maintain a viable

population.

Because Jay aches to be a spacer when he grows up, he is drawn to Paddy Enderton when this boastful spacer shows up and his mother lets him stay home for a change. Paddy sends him off to watch for enemies and pays him with trinkets whose likes have not been seen in ages, if ever. Of course, the enemies do show up, Paddy dies, the house is trashed, and Jay winds up in possession of Paddy's secrets, which hint at a treasurehouse of ancient technology—perhaps even including the fabled faster-than-light Godspeed Drive—hidden somewhere in local space.

The family doctor, Jay, and Uncle Duncan quickly rent a ship, enlist a pair of stuffy academics, and are on their way. Not too surprisingly, the ship proves to be crewed by Paddy Enderton's enemies. Their chief is an oddly likeable manipulator of those around him; he appreciates the possibilities of the Godspeed Drive. His crew believes Paddy had found a cache of *wimmin!* and are eager to go on a rampaging orgy of rape. Yet the destination worldlet to which Paddy's secrets bring them proves quite barren until Jay finds a secret entrance.

After a number of complications, including the need to keep a stubborn, curious young lady hidden in cramped quarters, nearly everyone gets what they want. The spacers have what looks to them like wealth untold. The surviving academic has a treasurehouse of information about the good old days, including insight into how the nature of the Godspeed

Drive destroyed the old galactic civilization and isolated Maveen. Maveen has hope for the future. And Jay ... well, he hasn't got the girl quite yet, but ...

If you wonder why all the characters bear such Irish names, Sheffield assures us all that Maveen was first colonized by a generation ship with an ethnically homogeneous cargo. The Godspeed Drive came only later.

Patricia Anthony is definitely an up-and-comer. Last month I praised her *Conscience of the Beagle*. Now we have **Brother Termite**, a more complex and ambitious work that—for me—suffers mostly from the implausibility of its premise.

That premise is that the aliens are indeed among us. In fact, they announced themselves to our government back in the fifties. Since then they have been advising presidents—and assassinating those they didn't like. What are they after? Well, they're humanoid, but they evolved from tunneling forebears whose sociobiology resembled our social insects (e.g., termites). A bit paranoid, they have long dealt with alien intelligences by exterminating them with engineered viruses. The invaders of Earth, however, have a problem: Their genes have gone awry; they are producing a greater and greater proportion of mindless "workers" or Loving Helpers. They have therefore chosen the kinder, gentler tack of reducing human fertility while trying to genetically engineer a hybrid species to replace both us and them.

President Womack is a rum-soaked

fruitcake with a tendency to piss on legislation he doesn't like. His chief of staff, the alien Reen, runs the White House. Hopkins, the Hooveresque head of the FBI, accuses Marian, the CIA chief with whom Reen has fathered a hybrid child, Angela, of being behind a wave of kidnappings and murders of the aliens. There are riots in the streets, perhaps because folks are twigging to the dropping birth rate or are resenting alien interference in human affairs. Something strange is happening with Gerber's strained peas. Some aliens are becoming a bit too human. Conservative aliens are urging immediate genocide and trying to bar Reen from the hive which is the only place a weary alien can sleep.

The aliens are plotting against the humans. The humans are plotting against the aliens. Poor Reen is caught in the middle, with Angela an emblem of the innocence that suffers when adults go crazy, and the ending is as inevitable as headlines, the hope that may redeem it all as evanescent as a dream.

I seem to recall seeing in the magazines one or two shorter pieces dealing with the background of this story. Certainly the novel evokes the feeling that there must have been such pieces, perhaps even the pair of previous novels that would make this the capstone of a trilogy. Yet those novels do not exist. *Brother Termite* stands alone, as more books should, and it does so quite well.

Kris Jensen's *Healer* is the third volume of a series (the earlier vol-

umes were *Free Master* and *Mentor*) set on the world of Ardel. Humans came there in search of minerals. They found intelligent natives with a complex life cycle, six-fingered hands, tentacles, auras, and powerful psychic abilities that frighten and bewilder most humans. The Union, which tries to play fair with natives, is trying to develop the mines. Nagashimi-Boem is a greedy industrial giant that will stop at nothing in its raping of a world; it wants Ardel and will get it if the Union cannot bring the mines on line in time.

Sinykin Inda is a doctor with a powerful drive to heal the sick. He has produced a vaccine for a local plague. His boss, the Union administrator, as terrified of Ardellian "magic" as Inda is enchanted, will not allow him to leave the base, even to save lives. So he leaves anyway, meeting old friends from the earlier novels, encountering resistance from Old Guard local healers, and in due time putting his vaccine to good use. Meanwhile, his wife Elissa, the engineer in charge of getting the mining machinery into operation, is running into signs of sabotage. There are noises in the workshop which Security dismisses as coneys that need to be trapped (note the name of one of the security officers).

There is mention of long-extinct aliens and their mysterious artifacts. I was not surprised at all when a questing native finds one of those artifacts and hikes off to deliver it to the same place Inda is heading toward. And here perhaps is the greatest weakness of the tale. Jensen keeps

his (her?) adventure moving right along, with enough event and interpersonal conflict and frustration to hold your attention if you do not crave philosophical depth or richly developed characters. Yet there is really very little in the way of suspense; Jensen is far too predictable for my taste.

On the other hand, little things like the coneys hint that if Jensen would let himself go, the result could be a very satisfyingly witty entertainment.

Charles de Lint's **Into the Green** is more conventional in its standing stones and fairies (here known as kowrie) and gypsies (or tinkers) than his trademark urban fantasy. In some ways it is more charming, for it evokes more explicitly the world of fairy tales and classic fantasy. In other ways, it is more grittily realistic, for it also evokes those serial killers who keep their victims' parts in the fridge.

The heroine is Angharad, one of the wandering tinkers who roam de Lint's Kingdoms of the Green Isles. A pair of witches come to their camp one night and say she has the sight; she too is a witch, with red hair and blue-gold flickers in the depths of her eyes and the ability to see "into the green," into a realm we might call faerie. She marries the younger of the pair, and when the plague kills all her kin, she seeks his return or her own death in a swamp where Jacky Lantern and his will-o'-the-wisp kindred dance in the night. What the kowrie give her instead is a harp and a gift for music. Now she is witch, tinker, and harper, a magic triad. She also has a generous

spirit that reaches to and befriends the oppressed.

Meanwhile, in a desert land across the sea, a nomad has discovered an ancient puzzle-box whose silver ornamentation has disturbing effects upon the mind. Told it is ancient magic and quite, quite evil, he sells it to a trader. In due time, it reaches the land where Angharad dwells, where many people hate and fear witches, where some people chase down witches and chop off their fingers to make earrings and necklaces of the fingerbones (they bring health and long life). She learns of it from a wizard who is—or is in—a tree and his apprentice; it threatens the green and all who know the green; it must be found and wakened and banished.

Angharad accepts the mission and travels to the city where it waits. There she finds witches being captured for dismemberment and is nearly lost herself. She meets a Zorro-type figure who slays aristocrats and helps her penetrate the lair of the arch-villain she thinks has the box. And then. . . I'll say only that events do not go in quite the way either Angharad or the reader expects even though they culminate very satisfactorily.

In terms of his plot, de Lint leaves no real room for a sequel. Yet I find myself hoping he will return to the setting and main character, for I would like to know more of Angharad and the Green Isles in much the way I—and many other readers—once wanted to know more of Andre Norton's *Witch World*.

* * *

I think Nick Pollotta's mother must have been frightened by the Three Stooges when he was still in the womb. There is simply no other reasonable—or unreasonable—explanation for the sort of stuff the man writes!

Last year, under the pen name of Jack Hopkins, he produced *Satellite Night Live*. Or that was the title he gave it. Lawyers from NBC and the "Saturday Night Live" TV show objected, and the book was *Satellite Night News* by the time it hit the stands. The story itself remained the same: a news team consisting of a woman, a man, a bearlike alien, and an android going forth to extract the news from silly situations rife with pratfalls, not to mention vicious competitors and dumb, jealous, power-hungry studio bosses.

I didn't read it. But when the sequel, *Satellite Night Special*, hit my mailbox I decided to take a closer look. And here's the verdict: Like the Three Stooges, Pollotta ignores sense, plausibility, physical reality, and any other aspect of the real world you care to name. His L5 LaGrange colony is between the Earth and Moon, where the gravitational attractions cancel out, not sixty degrees off to the side. There is a geosynchronous orbit around the Moon. And if you have the gall to object to such games of fast and loose, Pollotta flips you the metaphorical bird.

You say sense isn't the point? Well, sure. As I said about another Pollotta book once upon a time, he tells his stories strictly for laughs. His literary woodpile is a schtack of schticks. He

is incessantly, feverishly, inventively silly. He's not subtle in the least. He comes up with some horrendously bad jokes, and some good ones. He can't help but tickle your funny bone.

And the story he tells is as pell-mell as you could wish. Shortly after the Satellite News team arrives at an engagement party for Prince Yertzoff of Mars, the Prince vanishes. In the ensuing panic, the team evades both military investigators and competing journalists to find the obvious clue that the Prince was not kidnapped: he had a secret escape tunnel and a cached ship. Soon they are hot on his trail, their own bosses are on their tails, the military and competing news teams are catching on, and let the prats fall where they may.

You might have a bit of trouble locating the first book in the series. This one came out last October. But the third member of the series, *Satellite Night Fever*, came out February 1994. Have fun. And try imagining how this series would work as a Saturday morning cartoon.

Elizabeth Willey's first novel, **The Well-Favored Man**, is a smoothly written, perfectly charming fantasy billed as "for those who love Roger Zelazny's *Amber*" (among other things). The setting is a universe governed by magic. Three of the four elements, earth, fire, and water, are embodied as sources of the primal energy that sustains the world. Around each source has arisen a realm, with the most recent, Argylle, having accreted around the Spring. There are rivalries with the other

realms. There are sorcerers who draw upon the mystic powers of their local source; the most potent sorcerers are able to draw on all three sources. The near-immortal lords of the realms can travel on magical paths not only about their own world but to others, perhaps including our own. They thus have the potential ability to draw upon non-magical technologies, including some more advanced than our own. This, of course, allows me to shoehorn the book's review into a science fiction magazine. (Not that sheer whim isn't enough of an excuse.)

Now meet Gwydion, Prince of Argyll, ruling the realm because his mother, Freia, has been swallowed by the Spring to become its indwelling spirit. His father, Gaston, has disappeared to mourn, refusing all contact via those magical communication devices known as Keys. Other members of the family have also disappeared, notably Uncle Dewar, the super-sorcerer who trained Gwydion.

Gwydion is hunting a mantichore when his sister Belphebe tells him of seeing a gigantic dragon. In the interests of public safety, he must close certain roads and mount an expedition to try to kill the dragon. Fortunately, Uncle Dewar makes a brief appearance just in time to save his buns.

Of course, Dewar disappears again. He has his own business to attend to, he does, and he wants no meddlers. The same can be said of Gaston, who finally makes himself known by sending his and Freia's last daughter to join the family she has never met. There is a hint that if someone is

pushed into the Spring, Freia might emerge in that person's body, and Gwydion must resist the temptation to use his new sister, Ulrike, in that way, for she seems a pretty useless sort.

Further encounters with the dragon punctuate a story that is so full of background that it might well be the final volume of a trilogy. The final encounter, however, gives Gwydion a victory he really should have claimed long before; it seems designed mostly to get the dragon out of the way so the focus can recenter on Freia's plight and the borrowed technology that just may return her to the living.

As I said, it's smooth and charming. There are an inventiveness to world, magic, people, and customs and a difficulty to the problems the characters face that are quite enough to make the reader feel well rewarded. Also to its credit is its escape from trilogorrhea (though Willey may yet make a liar of me on that point).

Yet Willey's tale does have a fundamental problem that lies precisely in its "for those who love Roger Zelazny's *Amber*" billing: It is far too close a parallel to *Amber*, as if Willey had deliberately set out to exploit the popularity of Zelazny's series. Instead of Trumps, there are Keys. There are rival courts. There is a family of immortals with missing members. There is the ability to walk between worlds. The major difference seems to be that Willey's characters are nicer—nice enough, indeed, for a reader to enjoy visiting with them—and their rivalries are not so murderous. On the

other hand, some readers will surely think they're too nice, and that the story therefore lacks the juice that made Zelazny's work so appealing.

Do you have more money that you know how to spend legally, morally, and nonfatteningly? Do you have a thing for spaceships?

If you can answer both those questions with a resounding, "Yes!" then you just gotta have Ron Miller's **The Dream Machines: The Illustrated History of the Spaceship in Art, Science and Literature**. It begins about 360 B.C. with a steam or air-powered pigeon built by Archytus of Tarentum and proceeds date by date through dew power and balloons and cannons and rockets. It ends in the early twenty-oughts with Space Station Freedom, which is still, for all the plans made and remade and the money spent, little more than a dream that may or may

not come to pass.

Yet "dream" is really the point. Look at the book's title. Look at its content, whose emphasis is on more than two millennia of dreaming, including plenty of science fiction. The "fact" component enters late in the sequence of dates. Even after Sputnik appears on page 387, the history remains intimately intermingled with the dreams, both on the page (Star Trek's *Enterprise* beside a proposed Mars lander) and in the fates of the actual hardware. Think of Apollo.

Miller is a well-known astronomy and SF artist. The book he has assembled offers a fascinating survey of the development of an idea, with concise text loaded with illuminating tidbits and illustrations—mostly black and white but with a four-color insert—taken from old books and magazines, recent SF, and space program materials. ■

We are the hero of our own story.

Mary McCarthy

You grow up the day you have your first real laugh at yourself.

Ethel Barrymore

BRASS TACKS

I n the August 1993 *Analog* letters (p. 172) Paul Birch states that "Even on Earth, current technology would allow population to grow by at least [his emphasis] a further factor of 40,000..." No ecologist or demographer on Earth believes that this planet can support 1.8×10^{14} [$(4.5 \times 10^9)(4 \times 10^4)$] people. In fact, this planet does not even support 4.5 billion people, the present population. Birch is incredibly mistaken when he says, "The terrestrial environment is nowhere near destruction; we've *not* [his emphasis] spoiled it; we've *improved* [my emphasis] it." This flies in the face of clear and convincing evidence. For example, globally there is less potable water and arable land now than there was 20 years ago because of erosion, overgrazing, deforestation, desertification, wetlands destruction, and pollution. Thousands of species become extinct each year as habitat is destroyed by a flood of humans. I cite just two reports, taken more or less at random from the recent scientific literature: (1) Skole and Tucker, "Tropical deforestation and habitat fragmentation in the Amazon: Satellite data from 1978 to 1988," *Science* 260:1905-1910 (1993) documents the loss of "only" 230,000 km² of Am-

azon rainforest in 10 years, but concludes that 588,000 km² was "severely affected with respect to biological diversity." (2) Pringle et al., "Environmental problems of the Danube Delta," *American Scientist* 81:350-361 (1993) documents damage done to critical wetlands by ill-advised attempts to manage them. Far from improving the environment, in most cases humans have degraded the long-term productivity of terrestrial, aquatic, and marine ecosystems.

Even if you do not care if this planet's ecosystems are savaged, humans are not doing well. Millions starve to death or die of nutrition-related diseases every year, something that Green Revolutions can postpone locally, but do not prevent globally in the long-term. The rate of population increase in the Third World countries averages 2.1% per year, which could (if not checked by disease, famine or contraception) double the planet's population by 2020. The danger is that ecosystems could suffer such widespread damage that the planet might not even support the present population. This is not farfetched. Africa produces less food per capita now than it did 20 years ago, and the decline has been created by both increased population

and cropland and pasture degradation.

Perhaps present technology could barely cope with doubled population, but the prospect of 180 trillion people staggers the imagination. Not only is present technology wholly inadequate to support such masses of people, but we cannot possibly build the needed infrastructure (hydroponics, waste treatment, and transportation facilities) at the necessary pace, even if the necessary capital were no problem. And capital *is* a problem. Many communities worldwide lack potable water and even rudimentary waste treatment, not because the technology is not available, but because these basic services cost too much. Multiply these problems by 40,000. Would you want to live in that world, a true "Hell-on-Earth"? A frightening thought, but even more frightening that Birch could even think of it.

MALCOLM K. CLEAVELAND

Assistant Professor Geography
University of Arkansas

Fayetteville, AR

Dear Mr. Schmidt:

I am seriously disturbed by the comments of Paul Birch in the August "Brass Tacks": "The terrestrial environment is nowhere near destruction; we've *not* spoilt it, we've improved it. The so-called limits to growth are nonexistent."

First, the comments are blatantly illogical. If we've improved the terrestrial environment, why are there so many places where it is unhealthy to breathe the air, or stand unprotected in the Sun? Also, the Earth is a

closed system. All closed systems have limits.

Second, the comments seem to be based on sterile number-crunching that disregards the obstinate irrationality and inefficiency of humans and societies. Certainly, a jail cell, college dorm room, or cruise ship cabin are adequate to support life for an indefinite time. Even the jail cell would be luxurious by the standards of many people in the world. But ask any residents of same if they would care for a world where that was the only option? Perhaps Mr. Birch is happy in a studio apartment. I need my acre or so of grass, birds, and even gophers in the country. I would rather die than face a world where that could not exist.

The final question to Mr. Birch is one which can not be brushed aside: if the population limits to the planet are nonexistent, how come we cannot adequately feed, clothe, house, educate, and employ the population we already have?

Many things are possible in theory, Mr. Birch. Unfortunately, we have to live in reality.

SHARI PRANGE

Bonny Doon, CA

Dear Stanley Schmidt,

I enjoyed Duncan Lunan's story "With Time Comes Concord" (Sep. '93). After reading it, I feel there is more to the story than he has told. For example, who was/is that woman with the cut-proof prismatic underwear? Even for a parallel timeline, that technology seems out of place. She seems to play an important role

leading into the story, yet in the end she turns out to be little more than a spear-carrier. What gives? She's really from Mars or something, right, Duncan? She was/is on a mission to recover the crystal before some ignorant Earthling gets into trouble with it, right? I'm looking forward to the sequel.

BERNIE GALLAGHER

Piscataway, NJ

The author replies. . .

I'm glad you enjoyed "With Time Comes Concord." You are quite right that there's more of this story to be told. The first version I submitted was 8,000 words longer and included a lot more of John Pendleton's background, more Air Accident Investigation background, and a sub-plot in which suspicion for the "hoax" fell (with his permission) on my old friend Archie Roy, professor of astronomy at Glasgow University and himself a writer of science-based thrillers. There could be a novel in this as the ideas continue to develop.

There's also some sub-text which I think you may have missed. The girl is in our time-line too, in 1999. That's not far off now, but many of the developments my characters couldn't foresee in 1969 (such as the British Aerospace and British Airways mergers, the return of the IRA, cancellation of *Apollo*, and the advent of cheap pocket calculators) happened within five years. If her "armour" isn't yet under development, I'd be surprised.

Consider: AIDS has already changed social attitudes a lot. In a recent rape case, the defence argued

unsuccessfully that the victim had consented, by trying to get her attacker to put on a condom. Five years ago it's quite likely that argument would have succeeded. There's still a possibility that heterosexual AIDS will reach epidemic proportions. If it does, there will be a lot of property up for grabs; and those doing the grabbing will be, mostly, those who are already rich and powerful now. Not all of these will be nice people: notice the hint, since she's avoided the news limelight, that the girl may be one of John Brunner's "Totally Rich." There will be power marriages, arranged to consolidate the new groupings of wealth, and for that type of woman, being a virgin on marriage will once again be at a premium. There will be women who are sufficiently ambitious to find a new, comfortable form of chastity belt an acceptable restriction, especially if it also affords considerable protection against mugging or less casual assault. And it has its compensations: as long as she adds gloves and a hat with a broad brim or a veil, she can sunbathe or swim off southern hemisphere beaches which are otherwise by that time almost empty.

DUNCAN LUNAN

Dear Stan:

I know that magazine logistics prevents true dialog from emerging in *Brass Tacks*. Nonetheless, I am moved to address five points raised by Rachel Lerner [*Brass Tacks*, Aug. '93].

1. Regarding cancer rates, she asks "Why so many?" Answer: Because we are healthier. a) Everyone dies, so b)

everyone must die of something. Since c) cancer is largely a disease of age and d) Americans (et al.) live longer, e) cancer rates in industrial societies will be high. *But*, the age-adjusted cancer rates are no higher here and now than elsewhere and elsewhen.

2. "Environmental causes" would leave a pattern in the cancer data. Odd clusters here or there do not count, since such clustering will occur by chance. Any overall environmental effect must be beneficial, since age-adjusted US cancer rates are *declining*, except for breast cancer in women [holding steady] and lung cancer in both sexes [exponential]. (*From charts of long-term cancer trends presented by Nobel laureate Rosalyn Yalow at I-CON.*) As for the lung cancers, female rates lagged males by about twenty years, even though men and women breathe the same air. Behavioral factors (such as cigarette smoking, which women took up about twenty years after men) seem more likely causes than environmental factors.

3. However . . . I do agree with Ms. Lerner that animal screening for carcinogens is invalid. [Not all animal testing, mind you. Some of the animal models are quite well-founded.] But about half of all chemicals, natural *and* human-made, fail the cancer screen. Ms. Lerner worries that some human carcinogens may get a clean bill from animal testing; but we have spent billions in direct and hidden costs because of the converse: animal carcinogens with no epidemiological evidence that they cause cancer in hu-

mans. Alar is a recent example. Dioxin is another: it has *never* been linked to elevated cancer rates in humans, not even at Seveso, where a reactor explosion spewed a dioxin cloud over the village. Yet, we evacuated Love Canal and Times Beach at staggering cost. Yes, there were cancers at Love Canal, but no more than normal. [*Science*, Vol. 212, No. 4501 (June 19, 1981)] If extrapolation from animal tests to humans is "bullshit," as Ms. Lerner contends, the rationale behind much of the Green agenda collapses!

4. That a group of sick people insists that "X" is the cause does not mean that "X" really is the cause. We must distinguish between a fact and a belief. Being sick does not qualify one as an epidemiologist, nor as a statistician. Our hearts go out to the sufferers, but contracting cancer does not confer expertise. In earlier times, frightened sufferers would blame flouridation, or Jewish well-poisoners, or "witches." Now they blame power lines or dioxins, microwave relays or cellular phones.

5. Ms. Lerner's final warning, that "the odds are excellent that one day you will get" cancer is absolutely true. My brother did, at sixteen. My mother did, just this year. In the US, one-fourth of us will contract cancer in our lifetimes and one-fifth of us will die of it, mostly lung cancer from smoking. How much more satisfying to blame someone, especially someone "bad," and most especially someone "bad" with lots of money, than to acknowledge mortality, random chance, genetics, and behavior.

MIKE FLYNN

Dear Dr. Schmidt,

I don't usually lose my cool in print like this, but I've seen the words "medical establishment" once too often today, including most recently in a letter to the editor in *Analog*, and feel compelled to respond. (The letter in question is from Rachel Lerner in the August 1993 issue.)

Hi there. I'm a member of the "medical establishment" everyone hates so much. I actually spend very little of my time defending the "industrial status quo"; I'm far too busy trying to save people from their own vices. The primary one, in my practice in the Emergency Department at the Boston City Hospital, is interpersonal violence, followed by alcohol intoxication, then tobacco abuse, in about that order. I, too, have watched many people die of AIDS, of cancer, and of other nasty and unpleasant diseases; I have saved a lesser number as a result of things I know about physiology, pharmacology, and biomechanics. Much of this knowledge was first obtained from animals, then refined in controlled studies on humans. The crime is not that animal studies are done, but, as you eloquently noted, that some of it (perhaps even "much of it") is done poorly.

Now, in regard to cancer. As it happens, I have a personal stake, as my family history is, while remarkably free of heart disease, stroke or other cardiovascular badness, replete with malignancy. I, too, believe that many cancers are environmentally based. The prime environmental carcinogen today, in my opinion, is the cigarette (known in my trade as the "cancer

stick"). Some others are probably, as you say, due to other environmental factors; air and water pollution with organic materials not meant for long-term human consumption. I would point out that a significant fraction of preventable human cancers are due to sunshine and fresh air, to wit, the melanoma/basal cell group of cancers. To blame industry for "cancer" in general is easy—they are a big target, not well-liked by the public in general. On the whole, however, the argument is specious. By far the largest "cause" of cancer today is still smoking and nothing else. (Case study: in the early years of this century, a scientific study of lung cancer treatment was published in the *New England Journal of Medicine*. The accompanying editorial applauded the study but noted little application, as lung cancer was so rare that most physicians would not see a case in their lifetime!) While industry's role in smoking is not honorable overall, I still believe in individual responsibility enough to blame the smoker, not the company that made the smokes. Stop smoking, decrease your chance of early death from cancer about 17-fold. Your chance of death in general, however, remains constant—100%. Everyone will die of something, eventually.

Ms. Lerner, I do the best I can to protect you, and all the others like you who come to my attention each day. In many cases, there is little I can do. Most people won't stop smoking, won't stop drinking, and insist on revenge for what someone else has done to them. In addition, they like

having a job, a car, and many of the modern conveniences modern industry affords them. As an individual, I strive to sift through conflicting evidence on a daily basis regarding what is good for my health and the environment, and act accordingly. I would do this whether or not I was a physician, and whether or not I thought I would ever get cancer, because it's the right thing to do. I may be wrong, but I think most people are like me—trying to survive and thrive, and do the right thing.

THOMAS A. AMOROSO, M.D.

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Dear Dr. Schmidt:

Your editorial "Upstart Instruments" in the August, 1993 issue was an excellent critique of the relative merits of acoustic and electronic instruments for performing music. However, one point which was touched on only obliquely was the way this new technology has also aided those individuals who *compose* music.

Today, with readily available equipment (computer, synthesizers, sound modules, etc.), anyone can have a "home studio," where even the most complex music can be composed, played, recorded, and printed. Electronic-based systems provide the "weekend," amateur composer ac-

cess to essentially the same resources as the professional, and even obviate the need for hitherto necessary skills.

For example, to guide the composing process or hear what you have written, it is no longer necessary to be able to play an instrument yourself or have other instrumentalists at your disposal. My own piano-playing skills are limited to "hunt and peck" and very simple chords. With my computer-based system, however, it no longer matters how slow or error-filled my playing is. A software program allows easy editing of mistakes, and I can even use a mouse to enter notes individually from a menu onto the staves filling my monitor. No matter how slow the entry process or how many instruments I use, the computer plays back even the longest composition perfectly every time.

As you point out, there are valid concerns regarding the relative aesthetics of electronically produced music vis-a-vis the "live," acoustic variety. However, from a personal standpoint, the most important aspect of the recent advances in electronic music is that it has allowed so many would-be composers such as myself to fulfill their dreams. And, even though I know the St. Louis Symphony will never perform any of my orchestral works, I can still hear them in all their digitized "glory" in my own home.

HENRY STRATMANN, M.D.

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UPCOMING EVENTS

Anthony Lewis

3-6 March

WORLD HORROR CONVENTION at Fountain Suites Hotel, Phoenix, Ariz. Guest of Honor: Charles Grant and Dan Simmons; Artist Guest of Honor: Gahan Wilson; TM: Edward Bryant. Registration: \$75. Info: World Horror Convention, Box 60008, Phoenix AZ 85082-0008. (602) 841-5153 or 945-6890.

4-6 March

WISCON 18 (Wisconsin SF conference) at Holiday Inn, South East, Madison, Wisc. Guest of Honor: Karen Joy Fowler and Melinda M. Snodgrass; Special Guest: Jim Frenkel. Registration: \$20 in advance, \$30 at the door. Info: WisCon, Box 1624, Madison WI 53701-1624. (603) 233-8850 or wiscon-@macc.wisc.edu

11-13 March

SPACE ACCESS '94 (sponsored by the Space Access Society) at Grace Inn Ahwatukee, Phoenix, Ariz. Speakers include Jerry Pournelle, G. Harry Stine, Larry Niven, Tim Kyger, etc. Registration: \$70 until 15 February. Info: Space Access Society, 4855 E Warner Rd #24-150, Phoenix AZ 85044.

16-20 March

THE FIFTEENTH INTERNATIONAL

CONFERENCE ON THE FANTASTIC IN THE ARTS (academically oriented conference) at Ft. Lauderdale Airport Hilton, Dania, Fla. Guest of Honor: Roger Zelazny; Special Guest: Ben Bova; Permanent Special Guest: Brian Aldiss. Registration: \$80 until 3 March, \$145 at the door. Registration to: Mary Pharr, IAFA Treasurer, Department of English, Southern College, Lakeland FL 33801. Info: IAFA, 500 NW 20th St, HU-50, B-9, Florida Atlantic University, Boca Raton FL 33431-6498.

1-5 September

CONADIAN (52nd World Science Fiction Convention) at Convention Centre, Winnipeg, Manitoba. Guest of Honour: Anne McCaffrey; Artist Guest of Honour: George Barr; Fan Guest of Honour: Robert Runté; TM: Barry Longyear. Registration: \$85 (C\$95) adult, \$30 (C\$35) child until 30 September 1993; Supporting: \$25 (C\$30). This is the SF universe's annual get-together. Professionals and readers from all over the world will be in attendance. Talks, panels, films, fancy dress competition—the works. Join now and get to nominate and vote for the Hugo Awards and the John W. Campbell Award for Best New Writer. Info: Conadian, Box 2430, Winnipeg MB R3C 4A7 Canada or Box 7111, Fargo ND 58109 (204) 942-9494; FAX (204) 942-3427.

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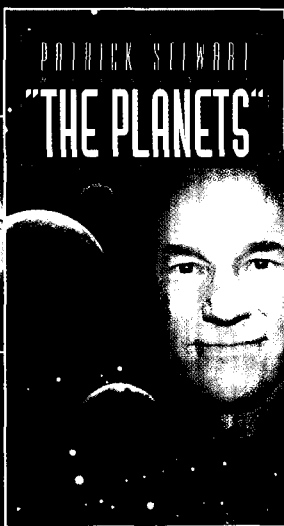
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